Pricing Model for Mortgaged Backed Securities using Python

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Key Features

MBS are backed by pool of pass-through securities and/or mortgage loans. Pass-throughs securities are securities where cashflows from the underlying security are passed to investors in the form of monthly payments less any servicing fee. Mortgages can be a combination of fixed rate mortgage loans and adjustable-rate mortgage loans. Adjustable-rate mortgage loans usually have both floors and caps, setting minimum and maximum interest rates on loan that could impact the cashflow to an MBS collateralized by adjustable-rate mortgages in a specific interest rate environment.

The MBS generally have multiple tranches which specific characteristics. They are a wider investment term and can be compared to a slice of the MBS security with different investment terms for receipt of interest and principal, different levels of risk and exposure to default from the collateral.

The cashflow structure in broad terms resembles that of a waterfall. It enables the issuer to divert the principal & interest generated by the collateral to different tranches and thus have different price, credit rating, and return characteristics for each tranche.

Based on existing literature, Interest rates have a much greater impact on this category of structured credit products, where in these rates not only impact the underlying mortgage loan prepayments but may affect the propensity of homeowners to refinance. The first part of building the model thus involves working on different interest rate models to generate different interest rate paths that an MBS cashflow could follow over its life.

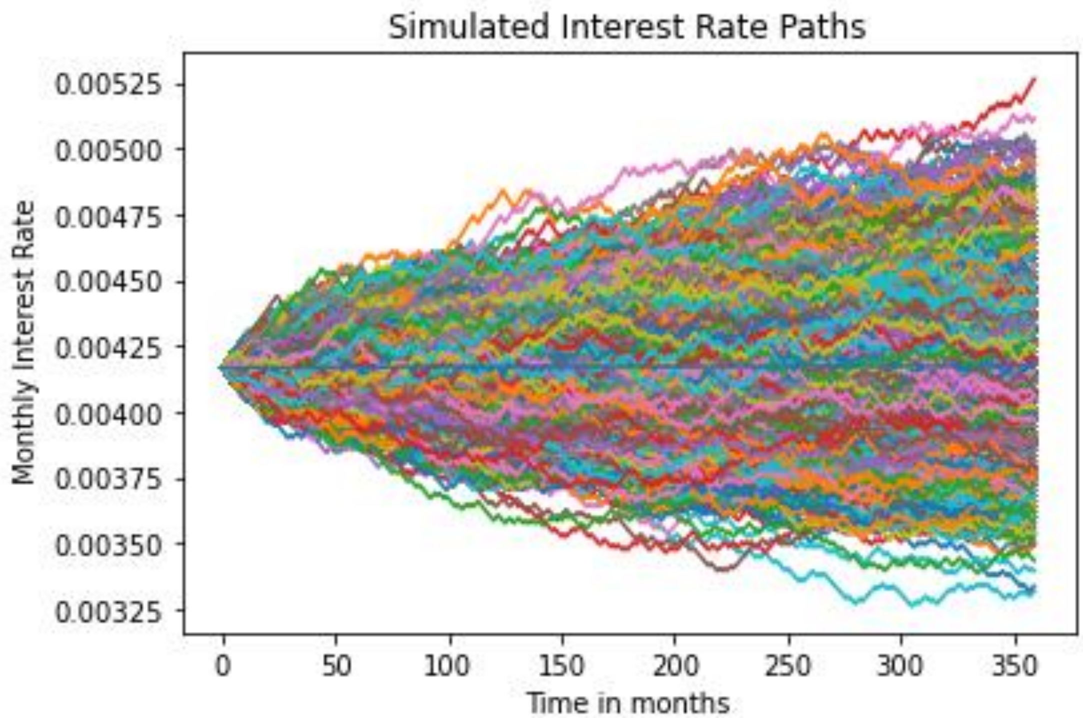
Interest Rate Models

The python module built to create Interest Rate Models primarily have two functions to define two different Interest rate models that could later be used.

1. Probability based Path: This is based on Binomial Interest Rate Model. This model is used to generate the interest rate path monthly over the theoretical life of the mortgage i.e., 30 years. The assumption of this model is that at every node/time-period the interest rate could either increase or decrease. This change depends on two factors, i.e., volatility and probability of change in a certain direction. Traditionally, this model is used to track movements of short-term rates. The base-case assumption is to place equal weights on probability of an increase or decrease. At each time under the base case, there is equal probability for interest rates to go up (Increase) or go down (decrease). This generated by a random function with its outcome as a binary number where 1 represents an increase and 0 represents a decrease. The movement upwards and downwards are calculated based off the binary interest rate model.

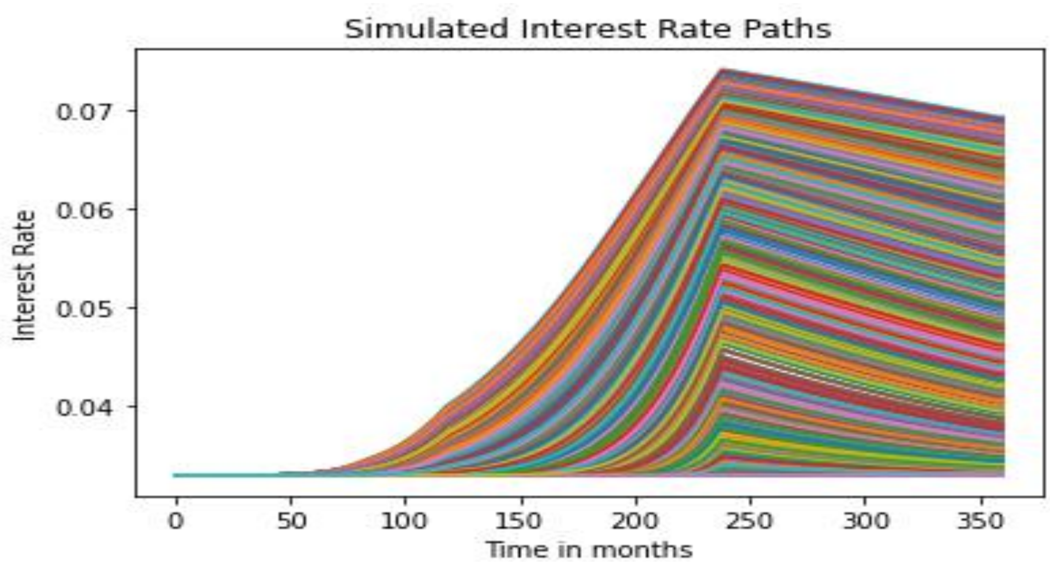
$$u = e^{\sigma \times \sqrt{t}} \; and \; d = 1/u$$

Where, $\sigma = Volatilty\ which\ is\ assumed\ to\ be\ a\ constant\ and\ t = 1\ month$



MBS however have longer maturities, and this is one of the drawbacks of using this model.

2. **Hull-White 2 factor model:** The key here is to predict future interest rates by fitting them to the calibrated term structure of interest rates today[1]. For the purpose of this model, an attempt was made to simulate 1000 interest rate paths that would fit the curve that explained the behavior of the current interest rates. The rates between two zero rates were established via simple linear interpolation for each price path. The mathematical equation used to generate this model



[1] Hull-White Model - codefinance.training

was based on the Gaussian 2-Factor additive linear model[2]. The Gaussian equation is easier to calculate, and its equivalence has been reiterated by existing literature in this area.

Prepayment path

Determining the most likely prepayment scenario is crucial to determine the accurate market value for an MBS.

Richard and Roll Prepayment model

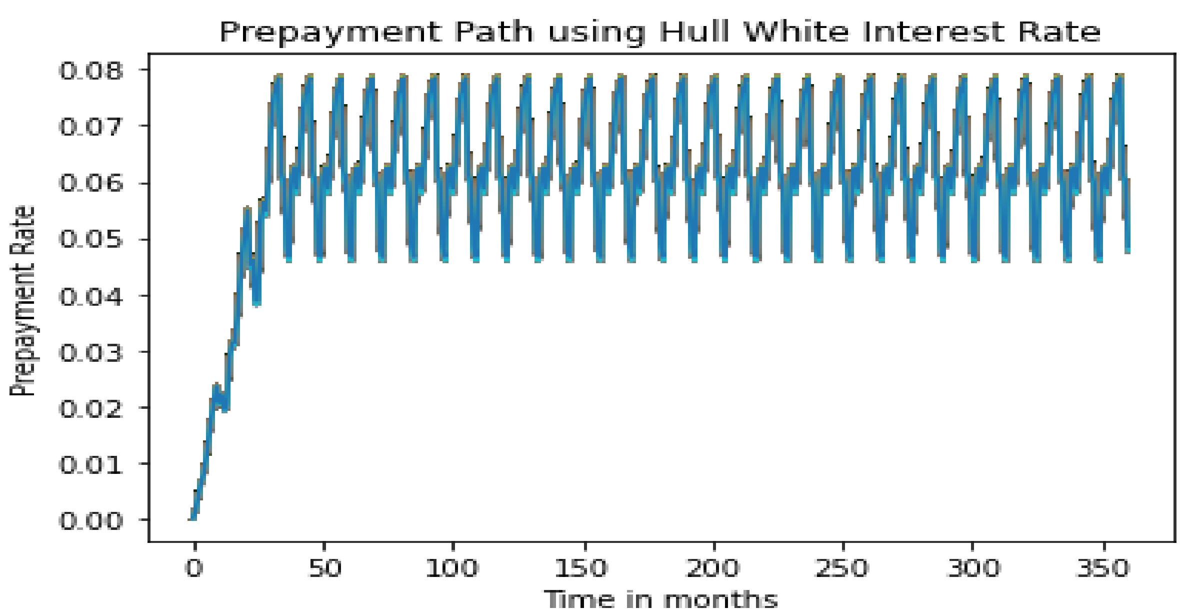
$$Prepayment\ Rate_t = Refinancing\ Incentive_t \times Seasoning_t \times Seasonality_m$$

Where,

t = time period in months

m = month of the year

Refinancing Incentive measures how much the borrower was to save if he refinances based on the current interest rate scenario. Seasoning multiplier accounts for the observation that as loans season or get older there is a peak in prepayments. Lastly, seasonality depends on the specific month of the year. Seasonality accounts for the change in prepayments that occur in specific months of the year. [3]The original model also accounts for a burnout multiplier that measures the decrease in propensity of the borrower to prepay over time. The burnout has been ignored due to lack of data based on the example followed. [4]



[2] Create two-factor additive Gaussian interest-rate model - MATLAB (mathworks.com)
[3] Prepayment Modeling with a Two Factor Hull White Model and a LIBOR Market Model - MATLAB & Simulink (mathworks.com)
[4] Simulating Yield of Non-Agency CMO in Python | by Maciej Sikora | Medium

Some Key Payment Terms:

Each Tranche has an estimated first payment date on which investors can expect to begin receiving the principal payment and an estimated last principal payment date on which they can expect to receive the final dollar of principal to be returned.

Both the First and Last payment dates are based on the prepayment assumption and can vary according to actual prepayments made on the mortgage. The period between the two dates is called the 'window'.

Payment dates are usually on the 15th/25th day of the month following the record date.

Cashflows from MBS:

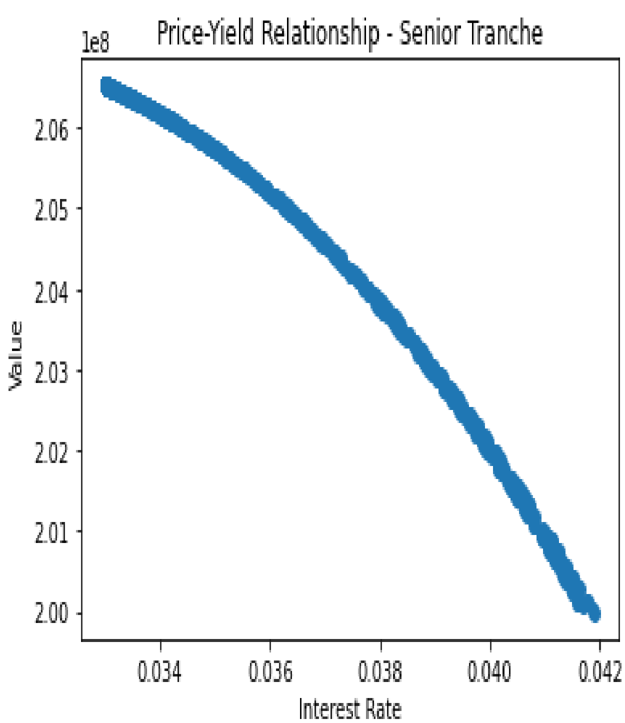
Cashflows from the MBS are first allocated to meet interest rate obligations on all tranches.

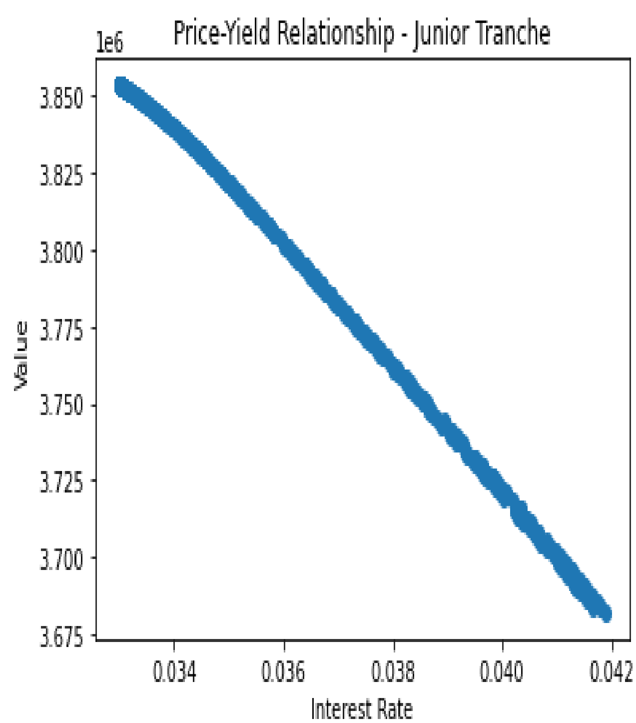
Principal repayments, both scheduled and prepaid are then distributed to different tranches or classes of bondholders based on the pre-determined priority schedule. The Tranche that receives principal repayment is referred to as active or currently paying.

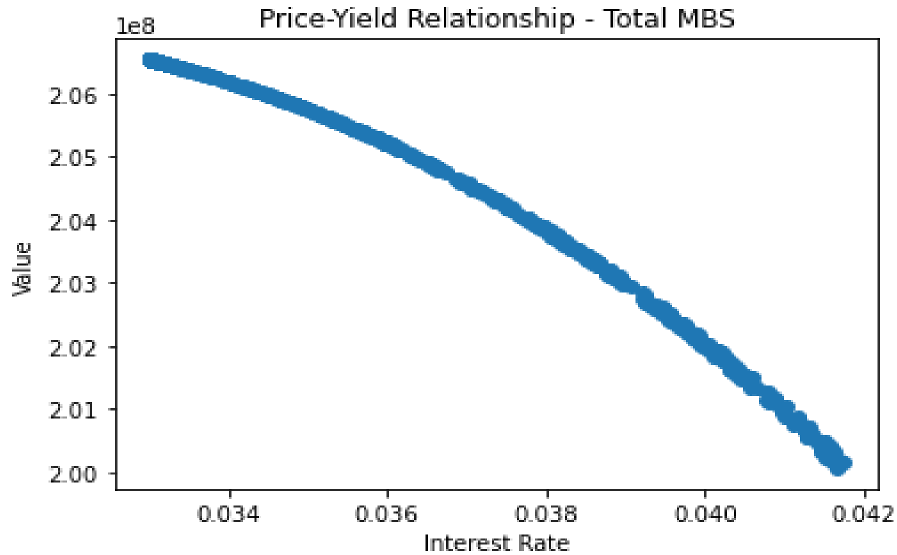
Sequential Pay:

Each tranche receives a regular interest rate but principal payments received are made only to the first tranche. The Tranches are retired sequentially, which means that principal payments on the second tranche begin after the first tranche has been retired completely. This means there is only one active tranche. The implication of this is that the average life of the senior tranches is lower than junior tranches. The Average age of the senior tranche is 12.58 years and the junior tranche is 17.75 years.

Price-Yield Relationship







The senior tranche displays negative convexity, whereas the junior tranche is less convex than the senior tranche. Negative complexity implies that when rates fall, the price for this tranche would rise slowly or not at all. Senior tranches would also be quicker to lose value if the interest rates were to fall due to increased prepayment risk because of the sequential payment method where there is only one active tranche. The price-yield relationship is more linear for the junior tranche. The junior tranche typically has higher coupons to compensate for higher credit and default risk. And in general, it observed that coupon payments are inversely related to convexity. But the price change for junior tranche is going to be greater and faster for any change in yield as compared to the senior tranches.