Milliman Mortgage Secondary Market Solutions

Introduction to mortgage pipeline hedging: Hedging with TBAs

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Introduction

Milliman's Mortgage Secondary Market Solutions (MS2) is a cloud-based software solution that allows mortgage originators and investors to calculate effective hedging strategies for mortgage pipeline risk and mortgage servicing rights. The software includes state-of-the-art models, data management, and trade management to evaluate pipeline exposure to market changes and calculate optimal hedge positions.

This paper provides an overview of hedging pipeline risk with to-be-announced securities (TBAs) in MS2 and some limitations of TBA hedging. It also provides some strategies that can be used to mitigate those limitations. (Please also see our related paper, "Introduction to Mortgage Pipeline Hedging," available at https://www.milliman.com/en/insight/mortgage-secondary-pipeline-hedging.)

Secondary markets function

The primary responsibility of a mortgage company's Secondary Markets department is to manage the financial risk inherent in originating, selling, and servicing mortgages and to preserve the capital of the mortgage company. These responsibilities include loan pricing, hedging, executing loan sales, and managing mortgage servicing rights. For hedging, Secondary Markets executes trades (i.e., hedges) where the value of the hedged asset appreciates (or depreciates) when the value of the mortgage asset depreciates (or appreciates). These hedges protect the mortgage company's capital from price fluctuations in financial markets. There are different approaches to hedging this risk, and the type of hedging strategy depends on several factors, including liquidity, cost, market conditions, and management strategy.

TO-BE-ANNOUNCED SECURITIES

The TBA market allows investors to buy unknown pools of mortgages in advance of their origination on the condition that the mortgages all have the same mortgage type (i.e., government or universal mortgage-backed securities [MBS]), tenor (e.g., 30-year mortgages), and security coupon rate (e.g., 5.0% or 5.5%). Investors purchase TBAs because they can have a slightly higher yield relative to on-the-run MBS securities. Mortgage originators sell into TBAs because they can be used to hedge the price risk assumed in the mortgage origination process. Price risk is assumed by mortgage lenders between the initial mortgage application and sale of the mortgage to a secondary investor.

Upon receiving a mortgage application, the lender will review the credit worthiness of the borrower and loan application to decide whether to approve the application.[1] If the application is approved, the lender will provide the borrower with terms for a mortgage (e.g., interest rate, amortization schedule), which are valid for a set number of days (e.g., 60 days). If the borrower accepts the terms, the lender will lock the interest rate for the borrower.

1. Often, loans are approved if they meet the underwriting requirements of Freddie Mac, Fannie Mae, or the requirements for mortgages sold in Ginnie Mae securities (i.e., FHA, VA, and USDA mortgages).

Once the lender locks a loan, the borrower has an option to borrow funds from the lender over the lock period. The borrower may or may not borrow the funds, but the lender has guaranteed terms to the borrower and priced the mortgage at the time of the lock. Variations in the number of loans that transition from lock to a closed loan (i.e., the pull-through rate) and the price of mortgages will impact the profitability of the mortgage company.

Mortgage lenders have many options for mitigating this risk, including selling loans forward at the time of lock to pass the price risk to the end investor. However, the price obtained by selling forward at the time of the lock is less than the price obtained for selling a closed loan. Therefore, mortgage lenders often hedge this risk using financial assets. This paper will focus on hedging lenders who use financial instruments to hedge the interest rate risk of the pipeline.

Selling TBAs provides the lender with price certainty at the time of sale. Lenders can sell forward into TBAs and deliver a pool of mortgages or lenders can trade TBAs (selling at the time of lock and repurchasing the securities prior to delivery) to hedge price risk. Selling forward requires a specified amount of delivery at a specified date and introduces additional risks to lenders. Therefore, most lenders trade TBAs to manage price risk using a duration matching strategy.

DURATION

Duration is a key concept in hedging with TBAs. Duration is a measure of the decrease in the value of a debt instrument (or other asset) to a unit increase in the rate of interest. Duration can be used to approximate the change in the value of an asset for a given change in interest rates. For example, assume the price of an asset today is $100, and the asset has a duration of 5. If interest rates increase by 100 basis points (1.00%), we can approximate the value of the asset as 100 × (1 − 5 × 1%) = 95 after the change in interest rates. For fixed income assets, the value of the asset decreases as interest rates increase. There are several calculations for duration, the most common being Macaulay Duration, Modified Duration, and Effective Duration[2]. Macaulay Duration is a measure of the weighted-average life of cash flows for the asset. The formula for Macaulay Duration is summarized as follows:

$$Macaulay\ Duration = \frac{\sum_t^n t_i * \frac{CF_i}{(1+r)^t}}{\sum_t^n \frac{CF_i}{(1+r)^t}}$$

where *CF* = cash flow in period *i*, *t* = period (integer), *r* = discount rate.

Modified Duration is an estimate of the decrease in value of the cash flow for a unit increase in interest rates; more specifically, this is the first derivative of the present value calculation with respect to the interest rate. After some algebra on the present value calculation, Modified Duration can be calculated as:

$$Modified\ Duration = \frac{Macaulay\ Duration}{(1+r)}$$

The value of a mortgage is equal to the present value of the expected future payments for the mortgage. Assuming no prepayment, Modified Duration can be calculated and used to approximate the change in value of a mortgage for a given change in interest rates. However, the cash flows for a mortgage are sensitive to changes in interest rates because the borrower has an option to refinance into a lower interest rate when interest rates fall. Therefore, the duration of a mortgage must consider both the cash flow stream and prepayment risk. Specifically, if interest rates fall, the expected number of payments will be less and the duration of the mortgage will be lower. If interest rates rise, the expected number of payments will increase and the duration of the mortgage will be higher.

2. http://www.mysmu.edu/faculty/yktse/fma/s_fma_8.pdf

To calculate Effective Duration, a simulation model is required to simulate future interest rate paths and cash flows that are dependent upon the simulated future interest rate paths. The present value of cash flows under each simulation path is calculated to estimate the price across various potential economic paths and takes into consideration borrower behavior under each simulated trial. Effective Duration is calculated as:

$$Effective\ Duration = \frac{P_{-} - P_{+}}{2 * P_0 * (r_{+} - r_{-})}$$

where P_{-} = Discounted cash flows of the mortgage when rates fall, P_{+} = Discounted cash flows of the mortgage when rates rise, P_0 = Discounted cash flows of the mortgage, $(r_{+} - r_{-})$ = Change in rates.

MS2 uses a risk-neutral simulation model to estimate the effective duration, taking into consideration prepayment and the default risk of the mortgage. Effective duration is reported in the software as an estimate of the sensitivity of the mortgage portfolio to changes in interest rates. It is calculated for each loan in the pipeline and aggregated to the portfolio level to calculate a portfolio level average effective duration.

For duration matching, the lock portfolio is hedged by entering TBA trades that offset the duration of the exposure. For example, if the lock portfolio has an exposure of $100 and an effective duration of 5 using the net coupon of the mortgage pool, the value of the portfolio is estimated to increase or decrease by $5 for a 100-basis-point move in interest rates. The hedge position should then be set such that the duration of the hedge exposure has an opposite sensitivity to interest rates. Assuming there is a TBA with an effective duration of 5,[3] the lock portfolio is duration hedged by selling $100 of that TBA security. If interest rates increase by 1.00%, the value of the lock portfolio decreases by $5 and the value of the hedge position increases by $5. The net change would be $0 and the mortgage bank would be risk-neutral to changes in interest rates.

The above example explains the concept of duration. In addition to duration, another assumption needs to be made on the lock portfolio to estimate the lock portfolio exposure. That is the pull-through rate.

PULL-THROUGH RATE

The pull-through rate is the percentage of locks that result in a closed loan. For a given period, the pull-through rate is calculated as the number of closed loans divided by the number of locks. Pull-through rates vary based on the application stage (e.g., initial lock or fully underwritten and approved loan), origination channel, product type, borrower attributes (e.g., higher credit score borrowers and owner-occupied properties have higher pull-through rates), and changes in interest rate from the initial lock to the current interest rate. In general, if interest rates fall from the initial lock, borrowers often seek a lower rate from another lender and pull-through rates decrease. Conversely, if interest rates rise, borrowers have an incentive to close the loan and pull-through rates increase.

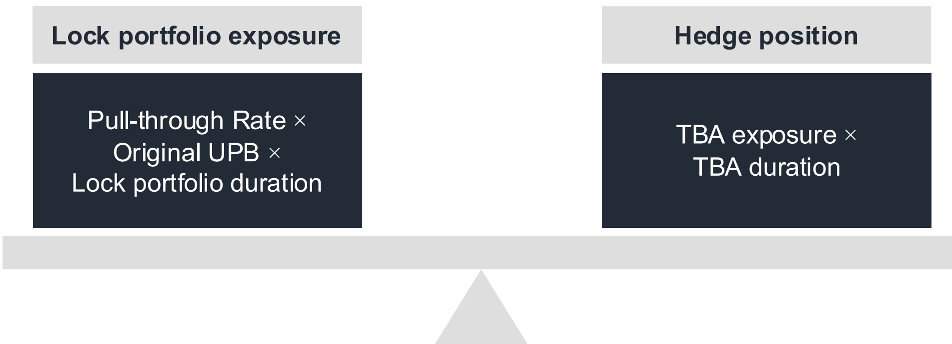
Mortgage banks hedging their pipelines price mortgages at the time of lock and then sell the loans when the loan closes. Therefore, the lock portfolio exposure is equal to the expected amount of closed loans at any given time and is calculated as the expected pull-through rate (estimated for each loan) multiplied by the original loan amount. The pull-through-weighted lock portfolio is the exposure that is hedged for price movements.

3. TBA durations can be extracted from financial systems such as Bloomberg using market implied assumptions; MS2 is calibrated daily to market implied assumptions to ensure the simulation model is risk-neutral.

DURATION MATCHING

The graphic below shows the hedge calculation using duration matching on a balanced scale. The left side of the scale represents the dollar exposure to changes in interest rates. It is calculated as the portfolio level pull-through rate times the original loan amount times the duration of the lock portfolio. The right side of the scale represents the hedge exposure to changes in interest rates. It is calculated as the nominal TBA exposure times the duration of the TBA portfolio.

For more granularity, hedging lenders may create multiple portfolios where the portfolio is segmented by the loan product, delivery window, or other factors.



For small changes in interest rates, the above scale can balance out well, making a duration hedging strategy effective in mitigating the interest rate risk assumed by hedging mortgage lenders. However, there are shortcomings with this approach that will be highlighted in the next section.

INTRODUCING CONVEXITY

Since pull-through rates are sensitive to changes in interest rates and the value of mortgage cash flows is sensitive to interest rates, the realized change in the value of a lock portfolio is nonlinear to changes in interest rates. Duration can be used to approximate the change in the portfolio for small changes in interest rates (e.g., changes of a few basis points); however, for larger changes in interest rates (e.g., 25 basis points or greater), this approximation is not accurate because it does not account for varying pull-through rates and prepayment speeds as interest rates fluctuate. The demonstration below provides an example of nominal cash flows and the value of cash flows at different prepayment speeds. This example does not include servicing cash flows or pull-through sensitivity.

- Original loan amount: $100
- Interest rate: 6.75%
- Servicing fee: 0.25%
- Guarantee fee: 0.50%
- MBS delivery coupon: 6.00%
- Prepayment rate: Varies based on the interest rate scenario

INTEREST RATE	NOMINAL CASH FLOWS	MODIFIED DURATION A	CHANGE IN RATES B	MODIFIED DURATION ESTIMATED PRICE C = 100 × (1 − 5.51 × B)	CASH FLOW MODEL PRICE (TAKING PREPAYMENT RISK INTO CONSIDERATION) D	PRICE DIFFERENCE E = C − D
5.30%	123		−0.70%	103.6	102.0	1.57
5.40%	124		−0.60%	103.0	101.7	1.29
5.50%	126		−0.50%	102.5	101.5	1.00
5.60%	128		−0.40%	101.9	101.2	0.72
5.70%	132		−0.30%	101.4	100.9	0.46
5.80%	136		−0.20%	100.8	100.6	0.22
5.90%	144		−0.10%	100.3	100.2	0.04
6.00%	**150**	**5.51**	**0.00%**	**100.0**	**100.0**	**–**
6.10%	157		0.10%	99.2	99.1	0.06
6.20%	166		0.20%	98.6	98.4	0.24
6.30%	179		0.30%	98.1	97.5	0.61
6.40%	179		0.40%	97.5	96.7	0.83
6.50%	179		0.50%	97.0	95.9	1.04
6.60%	179		0.60%	96.4	95.2	1.23
6.70%	179		0.70%	95.9	94.5	1.42

The above table shows that as interest rate movements exceed 25 basis points up or down, the modified duration approximation of the mortgage price is no longer accurate. This is because of the nonlinear relationship resulting from prepayment rates and discount rates for a fixed income asset. In a fixed income scenario, this nonlinear relationship is known as convexity. Convexity is the second derivative in the value of a stream of cash flows with respect to the interest rate.

Mortgage assets have negative convexity, meaning the value of the asset change as a function of interest rates forms a concave shape. This is because if interest rates decline, borrowers can refinance into a lower-rate mortgage and prepay the initial mortgage; thus, truncating the cash flow stream. If interest rates increase, the cash flow stream is extended (with fewer prepays) but the discount rate increases on fixed rate loans. The higher discount rate results in a lower price for the assets.

WHAT DOES THIS MEAN FOR TBA DURATION HEDGING?

When hedging with TBAs, mortgage banks accept basis risk between the duration profile of the lock pipeline and the duration profile of the TBAs. This is for two main reasons: One, mortgage banks generally deliver loans on a best execution basis and the duration of the best execution delivery may not have the same duration as the lock portfolio, and two, TBAs represent an average mortgage and are issued in 0.50% coupon increments. The duration and prepayment profile of loans in the lock pipeline will vary based on such factors as the credit quality of the mortgages and interest rate on the mortgages. As an example, using the mortgage behavior models in MS2, the table below summarizes the modified duration for various loans, all having the same interest rate and assuming a flat rate interest rate forecast:

LOAN ID	ORIGINAL LOAN AMOUNT	INTEREST RATE	CREDIT SCORE	DTI	OTHER FACTORS	MODIFIED DURATION
1	300,000	6.75	750	36		5.21
2	100,000	6.75	750	36		5.49
3	100,000	6.75	650	45		5.58
4	750,000	6.75	800	36	Investor property	5.81
5	300,000	6.75	750	36	Cashout refinance	5.49
6	300,000	6.75	650	45	Condo	5.25
7	300,000	6.75	750	36	Second home, rate/term refinance	5.77
8	750,000	6.75	750	36	First-time home buyer	5.37
9	300,000	6.75	650	50	High LTV	5.45

The above table uses a modified duration range from 5.21 to 5.81 to demonstrate how loan characteristics can impact the duration of the lock exposure. If we were to vary the interest rate on these loans while keeping the same best execution TBA coupon (e.g., at a 6.90% interest rate), the results would vary by an even greater magnitude. This means that when hedging interest rate risk, there is a basis risk between TBAs and the lock portfolio that must be considered when duration matching, and the convexity differences between the lock portfolio and TBAs could be more material during periods of larger interest rate movements.

INCORPORATING PULL-THROUGH ASSUMPTIONS

The discussion of convexity through this point has focused on the value of mortgage cash flows. In addition to convexity on mortgage cash flows, a hedging lender must have robust tools to model and evaluate the impact of changing pull-through rates on the net position.[4] For duration matching, a pull-through rate is assumed for the portfolio and the hedging lender rebalances their hedge position in reaction to changes in interest rates. This adds to trading costs and potentially realized losses on trades during market volatility as pull-through rates and best execution delivery are adjusted in reaction to movements in interest rates.

The table below highlights pull-through risk for mortgage lenders hedging pipeline risk using a TBA duration matching strategy. Assume the lender has a duration-hedged net position as follows:

LOCK EXPOSURE	VALUE
Original UPB	100
Pull-through	75%
Lock exposure	75
Lock modified duration	5.51
Exposure to unit change in interest rates	(4.13)
HEDGE EXPOSURE	
TBA duration	5.00
Offsetting exposure to unit change in interest rates	4.13
TBA notional	(83)

4. The net position refers to the sum of the interest rate risk on the lock pipeline and the interest rate risk on the hedge positions.

In this example, the lender has a lock pipeline of $100 with a 75% pull-through rate. Assume the loans are priced to sell for $103, representing a 3% margin for the lender. With a 75% pull-through rate, the lender's margin is $2.25 ($3.00 × 75%). The lock pipeline has a modified duration of 5.51 and the value of the lock portfolio is estimated to decrease by $4.13 if interest rates increase by 1.00% ($4.13 = 75 × (1 − 5.51 × 0.01) − 75). This level of price decline would be greater than the initial margin on the lender and is shown in the table below:

	VALUE
Original UPB	100
Pull-through	75%
Price	103
Initial margin (100 × 75% × 3%)	2.25
Exposure to unit change in interest rates	(4.13)
Loss from a change in rates	($1.88)

To offset this exposure, the hedging lender sold $83 of TBAs at the time of lock after determining the TBAs have a duration of 5.00. If interest rates increase by 1.00%, the calculated change in TBA value is $4.13 ($4.13 = 83 × (1 − 5.00 × 0.01) − 83), thus protecting the lender margin.

	VALUE
Original UPB	100
Pull-through	75%
Price	103
Initial margin (100 × 75% × 3%)	2.25
Exposure to unit change in interest rates	(4.13)
Gain from hedge	4.13
Net profit	2.25

However, if interest rates rise by 1.00%, it is likely the pull-through rate will increase. Let us assume the actual pull-through rate becomes 85%. In this example, the lender would lose $4.68 in margin due to the interest rate change ($4.68 = 4.13 × 85 / 75). From the above convexity discussion, we know the actual price would be lower than this calculation due to the negative convexity of the portfolio, but for this purpose, let us assume the modified duration calculation is accurate.

On the hedge side, the exposure is the same. The lender sold $83 of TBAs and needs to repurchase those TBAs prior to settlement. Since interest rates increased, the value of the TBAs would be estimated to be 83 × (1 − 5 × 0.01) = 78.85, resulting in a gain of $4.15.

Even with the hedge, the net impact to the lender is a loss of $0.53, or 23.5% of the expected day 1 margin (23.5% = 0.53 / 2.25).

WHAT CAN LENDERS DO TO MITIGATE THESE RISKS?

TBAs and duration matching are effective for hedging mortgage pipeline risk in environments with relatively stable interest rates. However, as highlighted above, doing this can expose lenders to losses during periods of larger interest rate moves. Fortunately, strategies are available to lenders that mitigate this risk.

One strategy is to frequently rebalance hedge positions. The above example assumes that hedge positions are set at the initial lock and are not updated through sale of the mortgage. In practice, hedging lenders rebalance their hedge positions daily as the lock pipeline changes and the rate environment changes. Frequent rebalancing incurs trading costs and can result in realized gains/losses that erode margin during periods of increased rate volatility.

A second strategy is to enhance the analytics used to calculate hedges using simulations that incorporate convexity calculations and pull-through estimates to determine effective duration and convexity. These metrics should be calculated for both the mortgage lock pipeline and for TBAs. It is important that the simulation model be calibrated daily (or more frequently as needed) to current market prices and implied market assumptions to produce risk-neutral estimates of interest rate volatility, security prices, and mortgage prices. A hedge strategy can be implemented that minimizes both net duration and convexity of the portfolio. This type of strategy mitigates risks to large interest rate and price fluctuations; however, it does not address the potential need to rebalance the portfolio frequently.

A third strategy is to supplement TBAs with additional financial instruments (e.g., treasury futures and bond forwards) to hedge the negative convexity risk of the mortgage pipeline. Treasury futures and bond forwards are interest-sensitive assets that can be added to protect lenders against large interest rate movements. The markets are highly liquid, and positions can be added at a reasonable cost to provide a meaningful reduction in risk during scenarios that would erode the margin of the mortgage lender.

MILLIMAN’S MORTGAGE SECONDARY MARKET SOLUTIONS: MS2

Mortgage companies assume financial risk when originating and servicing mortgages. This paper focused on using TBAs as an effective methodology to hedge pipeline risk. However, more advanced techniques are being developed and used in the market to better manage this risk.

Historically, advanced market hedging techniques have required quant teams and traders and were reserved for larger lenders. Milliman developed MS2 to provide these benefits to all lenders and to help mortgage companies manage their financial risk through either TBAs or hedging with interest rate futures and derivatives. MS2 streamlines these calculations and trading capabilities for mortgage originators. The software includes robust interest rate models (i.e., LIBOR market model) that are calibrated daily to current interest rate market volatility; is cloud-based, enabling efficient calculations and use; and is maintained by a team of financial consultants who manage interest rate risk for mortgage companies, fixed income investors, and insurance companies with embedded interest rate derivatives.

Milliman assists our clients with the development, implementation, and/or ongoing management of hedge programs. To explore these capabilities, contact us to schedule an introduction and demonstration of MS2’s capabilities.

Solutions for a world at risk™

Milliman leverages deep expertise, actuarial rigor, and advanced technology to develop solutions for a world at risk. We help clients in the public and private sectors navigate urgent, complex challenges—from extreme weather and market volatility to financial insecurity and rising health costs—so they can meet their business, financial, and social objectives. Our solutions encompass insurance, financial services, healthcare, life sciences, and employee benefits. Founded in 1947, Milliman is an independent firm with offices in major cities around the globe.

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