BARCLAYS

Index, Portfolio and Risk Solutions
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# US MBS Fixed Rate Risk Model

We introduce a second-generation risk model for the US MBS fixed rate securities in POINT®. This change constitutes a significant enhancement to our securitized risk model offering. The revised model forecasts volatility by decomposing risk into curve, curve volatility, prepay deviation and other spread risk. This systematic risk decomposition explains a significantly larger portion of total risk and allows the model to have a significantly simpler idiosyncratic risk framework. Backtesting results suggest strong performance on the Barclays US MBS Fixed Rate index.

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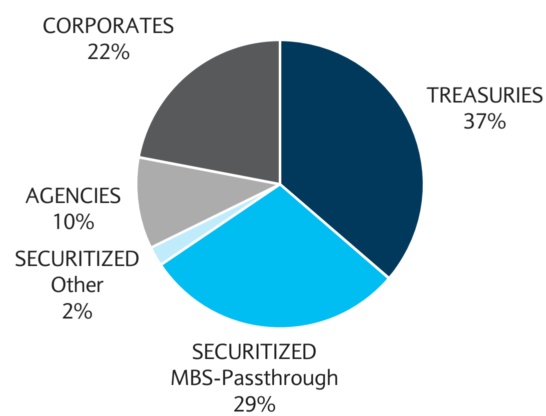
## Overview of the Agency MBS Fixed Rate Passthrough

A mortgage passthrough security is a type of MBS created by pooling mortgage loans and issuing certificates, entitling the investor to a pro rata share in the cash flows of the underlying collateral. Agency pass-through securities are issued by the Governmental National Mortgage Association (GNMA), the Federal National Mortgage Association (FNMA), and the Federal Home Loan Mortgage Corporation (FHLMC).

Since the first issuance of passthrough by GNMA in 1970, fixed-rate agency passthroughs have risen to be one of the most important fixed-income sectors in the US bond market. As of May 2013, the fixed-rate agency pass-through market accounts for 29% of the Barclays U.S. Aggregate Index (Figure 1). A typical US benchmarked asset manager who focuses on fixed income would allocate almost one-third of her assets to agency passthrough instruments. With minimum credit default risk, the MBS passthrough has typically traded at spreads close to agency securities (see Figure 2 for current values).

FIGURE 1

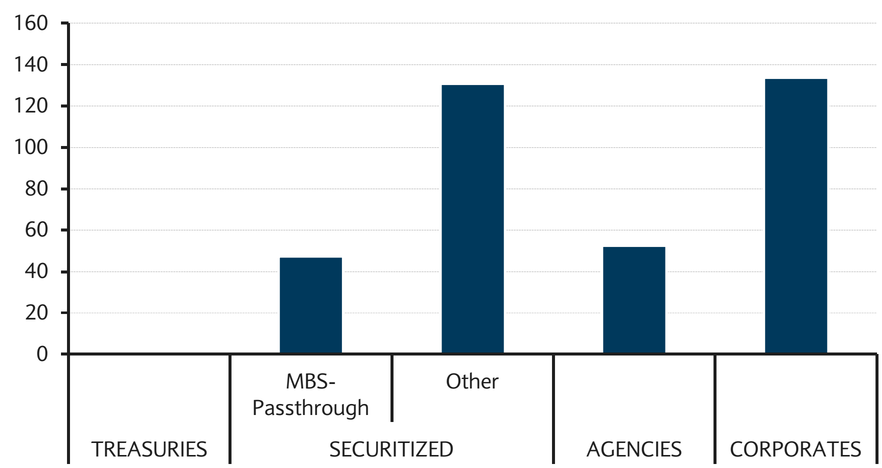
**Barclays US Aggregate Index Composition by Market Value, as of May 2013**




Source: Barclays Research

FIGURE 2

**Barclays US Aggregate Index Average OAS by Composition, as of May 2013**



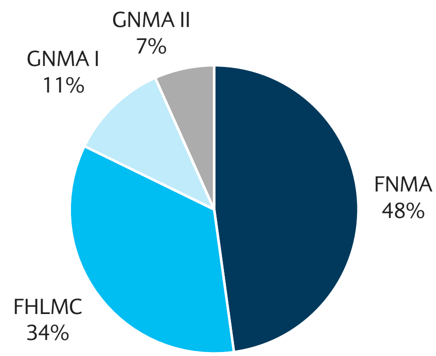

Source: Barclays Research

The agency fixed rate passthroughs are well described by the Barclays US MBS fixed rate index. Its constituents are over 400 agency generics aggregated from the universe of over 1,000,000 individual TBA deliverable fixed-rate MBS pools[1]. The collateral characteristics of the generics are aggregated from the corresponding pools according to agency (GNMA, FNMA and FHLMC), term of the program (30/20/15y), coupon and vintage.

Figure 3 to Figure 5 illustrate the market value composition of the US MBS fixed rate index, stratified by agency, term and coupon, respectively. FNMA accounts for almost half of the issuance and FHLMC accounts for one-third. 30y mortgages represent 80% of the market. These allocations have been stable over the past 15 years. On the contrary, we have seen significant change in the distribution of index composition by coupon. Concurrent with the dynamics of interest rate, the average coupon reduced from over 7.5 in the late 1990s to 5 in early 2013 (Figure 5).

FIGURE 3

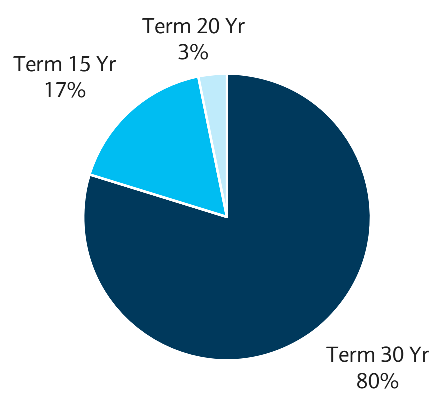
**Barclays US MBS Fixed Rate Index Composition by Agency**




Source: Barclays Research

FIGURE 4

**Barclays US MBS Fixed Rate Index Composition by Term**

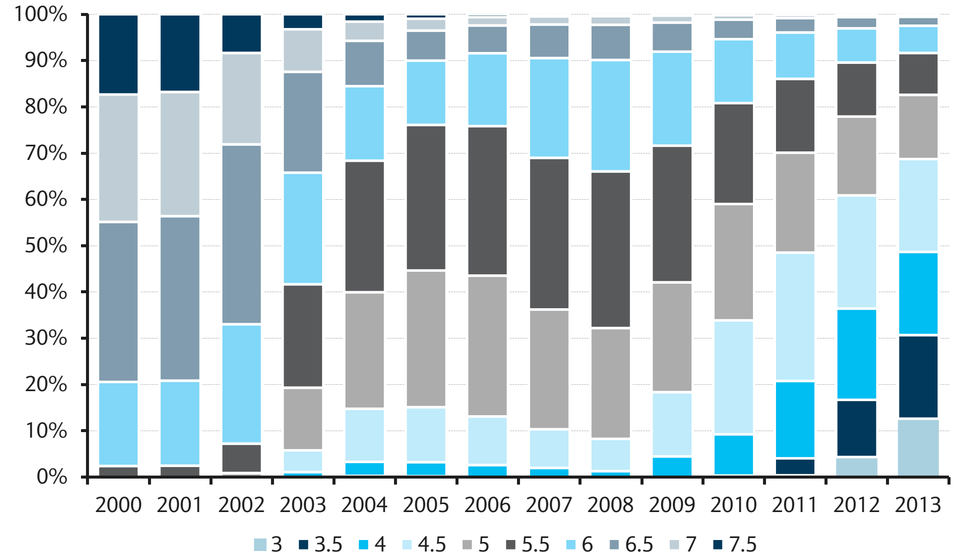



Source: Barclays Research

[1] Please refer to *A Guide to the Global Family of Indices*.

FIGURE 5

**Barclays US MBS Fixed Rate Index Composition by Coupon**

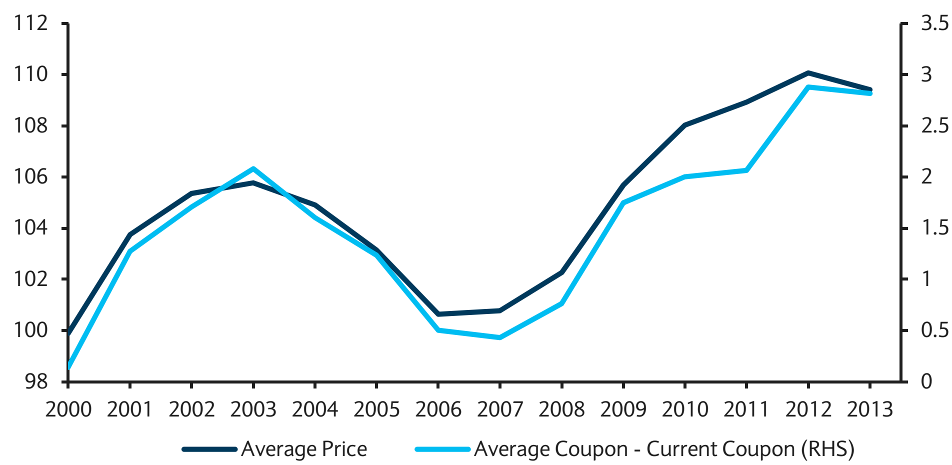



Source: Barclays Research

The generics are priced daily using matrix pricing based on trader TBA price quotations by agency, program, coupon and WALA. Historically, the average prices range from around par to 110 and are strongly correlated with the difference between the average coupon and the current coupon, defined as the coupon of the passthrough traded at par (Figure 6). A positive difference between the coupon and current coupon signals an excess interest payment above the risk-free discount curve. It also indicates a high mortgage prepayment tendency. This will be detailed in the risk model section.

FIGURE 6

**Barclays US MBS Fixed Rate Index Price vs Coupon Difference**




Source: Barclays Research

Once prices are populated, the generics are fed into Barclays' pricing model to calculate yield, OAS, OAD, Vega and other analytics that are critical for evaluation, performance attribution and risk management.

Our risk model is calibrated based on the analytics derived from the standard Barclays' prepayment model[2]. That being said, POINT allows for a substantial flexibility in prepay, default and recovery assumptions when calculating the analytics for mortgage securities. The Barclays' prepayment model predicts prepay and default speed by modelling term refinancing, housing turnover, cash-out refinancing and delinquency buyouts. The key factors are refinancing incentive, SATO, loan size, FICO, updated LTV, home price and geographic distribution.

The model's projected prepayment is the most fundamental assumption to calculate the risk analytics, such as OAD and OASD. As a result, the projected paydown is treated as deterministic and only the uncaptured prepayment deviation is included in the stochastic return for risk purposes.

## The New US MBS Fixed Rate Risk Model

### Motivation

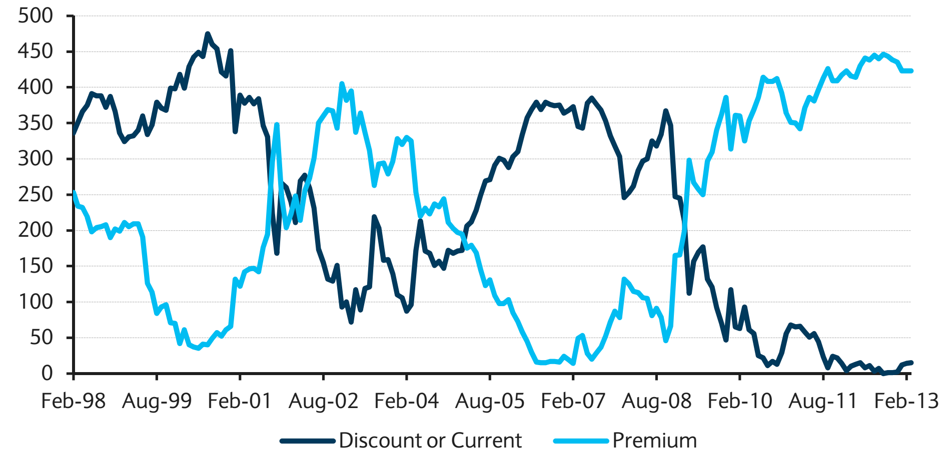
The US MBS fixed rate risk model is developed with security level data underlying Barclays US MBS fixed rate index. In the past 10 years, we have witnessed a significant change in the mortgage sector, brought on by the financial crisis, the unprecedented and persistent low level of interest rates, government and policy intervention in this market, etc. The underlying prepayment model has been upgraded several times to incorporate new market factors, underwriting standards and regulatory changes.

It is important to understand that the forecast performance of the current model for well diversified portfolios continues to be strong – that is not a major motivation for the model review. However, within the context described previously, there are several components of the current risk model for MBS securities that can be improved upon. First, as the interest rates stay at historical lows since the crisis in 2009, all "discount" and "current" securities (securities priced below 100 and 104, respectively) have almost disappeared from the index for more than a year (Figure 7). The current model has four factors calibrated from these securities – these factors are therefore no longer updated in the model. Similarly, the convention balloon risk factor is no longer active due to the exit of these securities in the index. In our risk model monthly calibration process, the existence of all these stale factors may be problematic. Volatilities and correlations of these factors get stale. This impairs the explanatory power of the model and is a potential source of unstable results. Moreover, the existence of these factors prevents the model from adapting the volatility forecasted to new market conditions.

[2] Please refer to *Inside mortgage valuation: A guide to models on Barclays Capital Live*

FIGURE 7

**Number of Securities in MBS Fixed Rate Index**




Source: Barclays Research

Second, in the current model, the idiosyncratic variance accounts for an average of 20% of total return variance. It has been a common impression that agency mortgage passthroughs are relatively homogeneous securities when compared with other bonds (e.g., corporates), so that the majority of the return volatility should be captured by the systematic components. The current level of idiosyncratic risk seems not to reflect that.

A related issue concerns the idiosyncratic correlation the current model imposes across different mortgage bonds. Because the systematic factors fall short of explaining the current market volatility, that role falls on the idiosyncratic model, including the imposed cross issue idiosyncratic correlations. The current correlation model is complicated and unintuitive. However, it does influence the forecasts for standard portfolios. We would like to change this picture.

Motivated by all of the above, we have developed a new model that explores a broader factor space, better utilizes the most updated analytics coming from the recent prepayment and pricing models, is more flexible to the current market environment and potential changes, and significantly reduces the shortcomings of the current model.

## The New US MBS Fixed Rate Risk Model

Evolving from the current model, the new MBS fixed rate risk model considerably extends the factor space to incorporate directly prepayment risk factors and additional spread factors. Notable candidates for this task are refinancing incentive, SATO and High Spread factor.

The new model relies on the Barclays US MBS Fixed Rate index data for security prices, analytics and collateral characteristics. Due to the limited availability of some analytics historically, such as prepayment duration, the new model is estimated with data starting from April 2005. Accordingly, the forecasted factor covariances are available in POINT starting from March 2007 for MBS securities.

### *Splitting Total Return to Construct the Stochastic Return*

In this section, we establish the conceptual framework for our risk models by discussing the underlying return structure of mortgage products. There are two distinct ways to segment total return, one being the cash flow approach and the other the performance attribution approach.

The cash flow approach splits the total return into coupon, price, and paydown components according to the cash flow distributions. The monthly proceeds of a MBS passthrough bond are the principal and coupon payment plus its market value change over the month. This partition is provided for all securities in Barclays Indices. In formulas:

$$R_{t+1}^{Total} = \frac{P_{t+1}B_{t+1} - P_tB_t + cB_t + 100 \times (B_t - B_{t+1})}{P_tB_t} = R_{t+1}^{\mathrm{Pr}ice} + R_{t+1}^{Coupon} + R_{t+1}^{Paydown}$$

where

$$R_{t+1}^{\mathrm{Pr}ice} = \frac{(P_{t+1} - P_t)}{P_t} \times \frac{B_{t+1}}{B_t}\text{ , } R_{t+1}^{Coupon} = \frac{c}{P_t}\text{ , and } R_{t+1}^{Paydown} = \frac{(100 - P_t)}{P_t} \times \frac{B_t - B_{t+1}}{B_t}\text{ .}$$

We further categorize each sub component into stochastic and deterministic return. According to the price return, and given that at maturity, all passthroughs' prices converge to par, we define the deterministic component of the price time return as $\frac{(100 - P_t)}{P_t \times WAM_t}$. The rest of the price return is treated as stochastic. $WAM_t$ denotes the weighted average time (in months) to maturity. Coupon return is deterministic by nature, and so it bears no stochastic component. For paydown return, as mentioned earlier, the model projected principal payment is the deterministic cash flow component. The difference between the actual and the forecasted prepayments is called the prepay deviation. This is the stochastic component of the paydown return. In formal notation:

$$R_{t+1}^{Stocahstic} = R_{t+1}^{Total} - R_{t+1}^{Price\_time} - R_{t+1}^{Coupon} - R_{t+1}^{Model\_Paydown}$$

The second return split approach utilizes POINT Hybrid Performance Attribution (HPA) model[3], in which curve carry, volatility decay and OAS carry are termed as the deterministic return.

The curve carry is approximated by the yield of a hypothetic Curve-Matching Portfolio (CMP) that is comprised of a set of par Treasury bonds and cash. The allocation to the par bonds and cash is determined by matching the key rate durations and the market value. Volatility decay captures the change in option value due to the lapse of time and is approximated by the difference between the OAS and ZV spread. The last component, OAS carry, covers the time return, or 'pull to the par' effect of spread. Curve carry and OAS carry have been the two major sources of deterministic returns for MBS passthroughs. In the HPA approach, the coupon return and expected paydown return are both embedded in the curve carry.

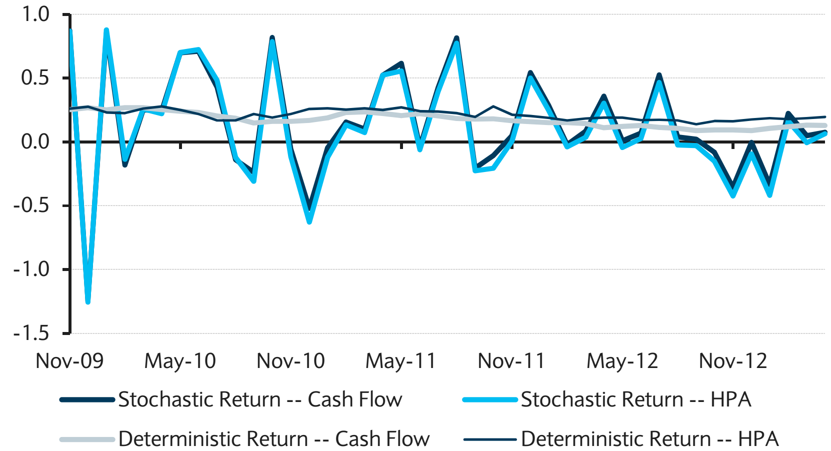
We have found that the stochastic returns derived from the two approaches track each other closely in aggregate terms (Figure 8). In the implementation, to be consistent with the POINT HPA model, the risk model employs the HPA approach to construct stochastic return and uses the cash flow approach only before October 2009 when the HPA historical data are not available. In formula:

$$R_{t+1}^{Stocahstic} = R_{t+1}^{Total} - R_{t+1}^{Curvycarry} - R_{t+1}^{Voldecay} - R_{t+1}^{OAScarry}$$

[3] Please refer to *The Barclays Capital Hybrid Performance Attribution Model*

FIGURE 8

**Stochastic and Deterministic Return (%/month) between Cash Flow and HPA Approach**




Source: Barclays Research

It is important to clarify what we refer to as 'prepayment risk' in the context of a risk model. Prepayment risk refers to the underlying uncertainty about the level of prepayments that the security will have. Note that the risk is on the uncertainty around the forecasted or projected paydown, not on its level. Therefore, for risk purposes, we are not concerned with how different prepayment speeds affect the price of a security, but how unpredictable these prepayments are. In both return split approaches, the model projected prepayment speed is embedded in all the risk analytics of the security and not directly included in the stochastic risk. In this regard, the factors that are critical in the prepayment model to predict prepayment level may not be as relevant to determine prepayment volatility. We will return to this point later in the paper.

## *The Systematic Risk Model*

The MBS fixed rate risk model follows the general framework of the Barclays Global Risk Model (GRM) in POINT[4]. Stochastic returns are represented as a linear combination of systematic factors, with pre-defined loadings, and an idiosyncratic residual. Factors embody risk sources common to MBS passthroughs, including Treasury curve, swap spread, curve volatility, prepay-related spread and other spread factors. Loadings provide the exposure of each security to each risk factor.

### Curve Risk

Return volatility due to curve movement (including Treasury curve and swap spread) is the dominant source of risk for the majority of fixed income securities. This is specifically the case for MBS passthroughs. For MBS bonds, curve risk affects prices both through discount rate and future cash flows. For the discount effect, a drop of interest rate leads to an increase in price. The cash flow effect, however, varies according to the type of MBS bonds. Bonds priced above par (premium) are devaluated upon a faster prepayment caused by a drop of interest rate, while bonds below par (discounts) benefit from it. Capturing both effects, the Treasury risk is formulated as the following:

$$R_{i,t+1}^{Tsy} = \sum_{K=1}^{6} KRD_{i,t}^{K} \times (-\Delta KR_{t+1}^{K}) + OAC \times \frac{1}{2}(\Delta \overline{KR})^2 \quad (1)$$

We use six observed key rate factors (monthly change in key rates of 6m, 2y, 5y, 10y, 20y and 30y) and one convexity factor to capture the return coming from changes in the

[4] Please refer to *A Portfolio Manager's Guide to Multifactor Fixed Income Risk Models and Their Applications*

Treasury curve. The bond's loadings to these factors are the key rate durations and the OAC. Swap spread factors receive similar treatment with the factors defined as monthly changes in the key swap spreads (6m, 2y, 5y, 10y, 20y and 30y) and loadings as their corresponding swap spread durations:

$$R_{i,t+1}^{SS} = \sum_{K=1}^{6} SSD_{i,t}^{K} \times (-\Delta SS_{t+1}^{K}) \quad (2)$$

**Volatility Risk**

MBS passthrough can be viewed as a bullet bond shorting a call option held by the mortgage borrower. The option represents the ability of the borrower to prepay his mortgage. An increase of vol leads to an increase of the option's value and a decrease of the mortgage's value to the investor. MBS passthroughs' volatility return is modeled as:

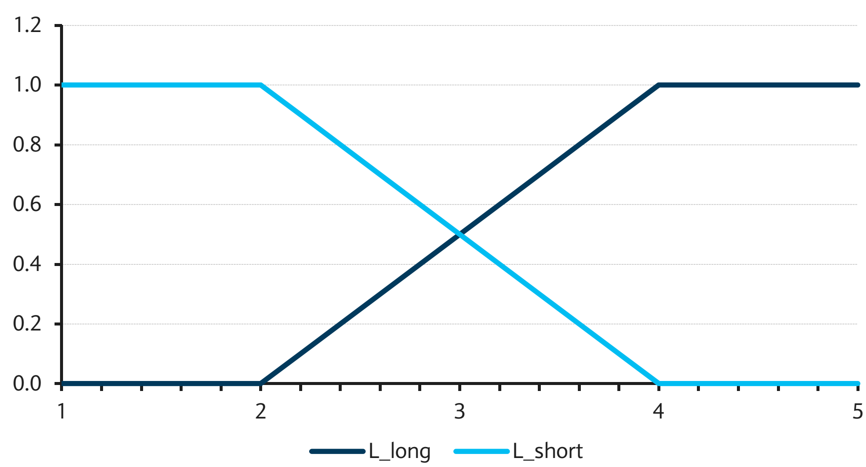
$$R_{i,t+1}^{Vol} = VolDur_{i,t} \times (L_{i,t}^{Short} \times F_{t+1}^{ShortVol} + L_{i,t}^{Long} \times F_{t+1}^{LongVol}) \quad (3)$$

$R_{i,t+1}^{Vol}$ is calculated at the security level using POINT's HPA model; it is the price return attributed to the yield curve volatility surface change from *t* to *t+1*. $VolDur_{i,t}$ is the price sensitivity to a parallel shift of the vol surface, and is a function of the vega of the security[5]. $L_{i,t}^{Short}$ and $L_{i,t}^{Long}$ are defined based on a security's sensitivity to the short and long parts of the rate volatility surface. As shown in Figure 9, MBS with OASD below 2 only has exposure to $F_{t+1}^{ShortVol}$, while MBS with OASD above 4 only to $F_{t+1}^{LongVol}$. All other MBS has a weighted exposure to both volatility factors. This specification allows us to capture the non-parallel changes in the implied volatility surface without resorting to expensive partial vega computations.

We use robust regression techniques to estimate the factors in equation (3), in which outliers are given less weight in the estimation. The R-square for this cross section regression is about 0.95.

FIGURE 9

**Vol Factor Loadings by OASD**




Source: Barclays Research

[5] A more detail discussion of the volatility duration can be found in *A Note on Changes to the US MBS Risk Model in POINT*

Both curve (Treasury and swap spread) and volatility risks in the new model follow directly from the current model's approach. The major update of the model lies in the representation of the MBS spread risk, originating from either future cash flows or discount factor. The former is mainly due to the prepayment deviation whose exposure is well captured by the prepayment duration. The latter includes any spread factor additional to the Treasury and swap curves and its exposure is best represented by OASD. We summarize all the key factors that contribute to each spread risk component in the following sections.

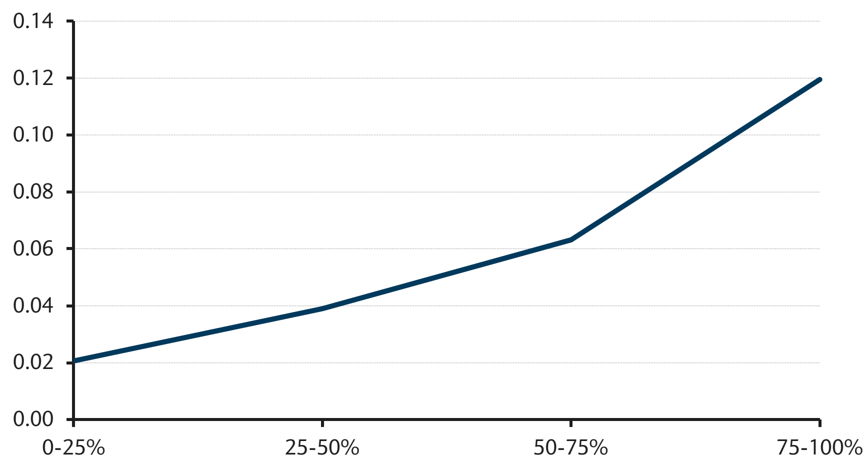
$$R_{i,t+1}^{Spread} = R_{i,t+1}^{Stochastic} - R_{i,t+1}^{Tsy} - R_{i,t+1}^{SS} - R_{i,t+1}^{Vol} = R_{i,t+1}^{\mathrm{Pr}epay} + R_{i,t+1}^{OtherSpread}$$

### Prepayment Deviation Risk

Prepayment deviation risk has lately been a small contributor to the MBS passthrough risk, a sign of the good prediction ability of current prepayment models. A natural loading to the prepayment deviation is the prepayment duration, measured by the percentage change in price with respect to a percentage shift in the model prepayment speed. Figure 10 shows an upward sloping relationship between the prepay deviation volatility and prepay duration. The figure groups the estimation sample (panel data) into quartiles according to the Libor prepayment duration. Generally, this duration is negative for discount bonds (prefer faster prepay) and positive for premium bonds (prefer slower prepay).

FIGURE 10

**Volatility of Prepay Deviation Return (%/month) by Prepay Duration Quartiles**

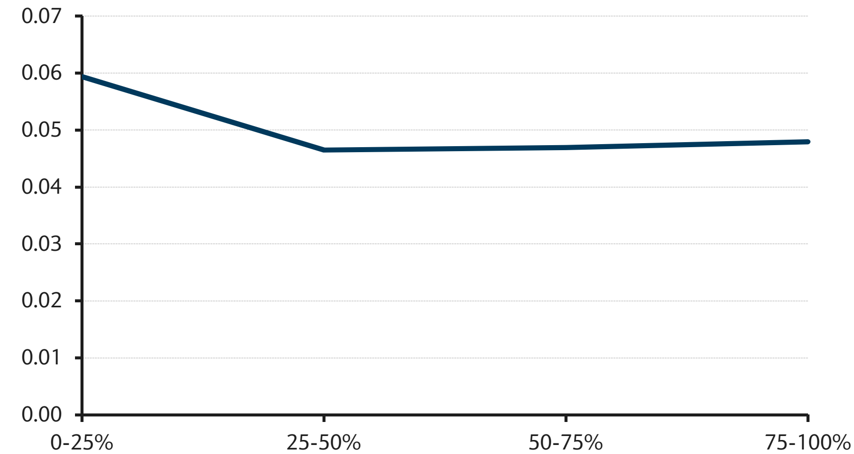



Source: Barclays Research

As previously discussed, factors that explain well prepayment levels may not be so relevant in explaining prepayment volatility. Our research shows that the key factors explaining the prepay deviation risk are refinancing incentive (RI) and spread at origination (SATO). In particular, we have identified insignificant explanatory power from FICO, LTV, WALA and balance when added to the regression on top of RI and SATO factors (their contribution to the regression R-squared is negligible). Figure 11 shows the non-monotone relationship between the prepayment deviation volatility and FICO. Although FICO has been one of the most important factors in predicting prepayment level, it barely correlates with the prepayment deviation (at -9% correlation).

FIGURE 11

**Volatility of Prepay Deviation Return (%/month) by FICO Quartiles**




Source: Barclays Research

- Refinancing Incentive (RI)

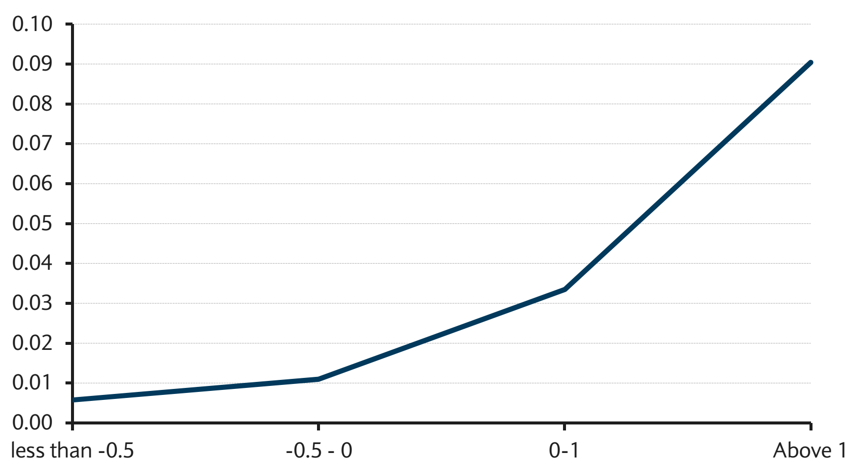
We measure refinancing incentive as the coupon minus the corresponding current coupon rate mapped by issuer and programs. As mentioned before, it is the most critical factor in the prepayment projection and it is not surprising that it is the most significant factor for prepayment deviation risk. The positive correlation shown in Figure 12 confirms a higher prepayment uncertainty associated with collaterals with higher refinancing incentive. Specifically, the loading to the Refinancing Incentive factor in our risk model is defined as:

$$PrepayDur_{i,t} \times (RI_{i,t} - RI_t^{MIN})$$

Where $PrepayDur_{i,t}$ and $RI_{i,t}$ are specific to the bond and $RI_t^{MIN}$ is the lower bound in our estimation universe at any point in time. *RI* is represented in percentage.

FIGURE 12

**Volatility of Prepay Deviation Return (%/month) by Refi Incentive (%)**




Source: Barclays Research

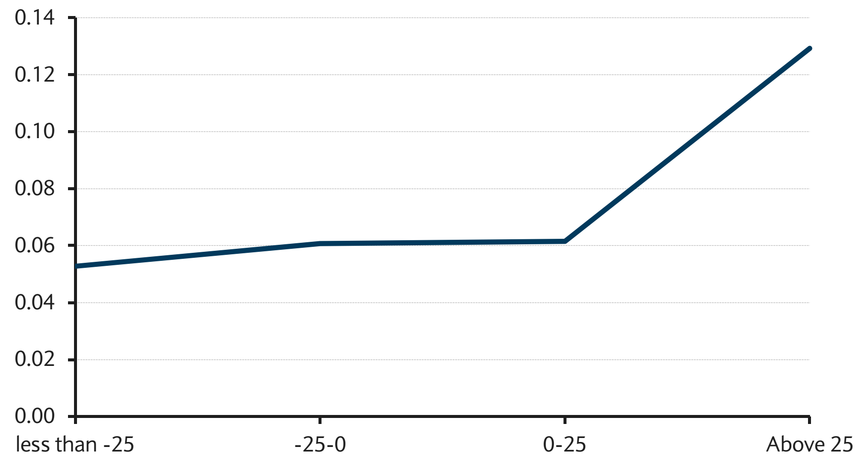
- Spread at Origination (SATO)

We measure SATO as the difference between the WAC of a particular pool and all pools originated in that month. Accordingly, the generic's SATO is aggregated from the underlying pools. SATO reflects the borrower's credit quality based on his underwriting requirement such as documentation and employment history. We have also found a positive nonlinear relationship between SATO and the prepay deviation volatility (Figure 13), implying a higher prepayment uncertainty attached to collaterals with worse credit quality. Because SATO is comparatively a less important factor in the systematic regression, we do not apply a nonlinear functional form in SATO given the minor marginal benefit it gives to the model. The loading to the SATO factor is defined as:

$$PrepayDur_{i,t} \times (SATO_{i,t} - SATO_t^{MIN})$$

Similar to Refinancing incentive loading, $PrepayDur_{i,t}$ and $SATO_{i,t}$ are specific to the bond and $SATO_t^{MIN}$ is the lower bound in our sample at a particular point in time. The *SATO* unit is in basis point.

FIGURE 13
**Volatility of Prepay Deviation Return (%/month) by SATO (bp)**




Source: Barclays Research

**Other Spread Risk**

Other spread risk captures the risk attached mainly to the discount factor, including agency risk premium and liquidity premium. It is captured by four additional factors: Spread Ultra High Grade, High Spread, Spread GNMA and Spread Non-30 year.

- Spread Ultra High Grade (UHG)

UHG risk is the base level of spread risk that will be applied to all MBS passthrough bonds, independently of their spread level and programs. The loading to this factor is the bond specific *OASD*.

- High Spread

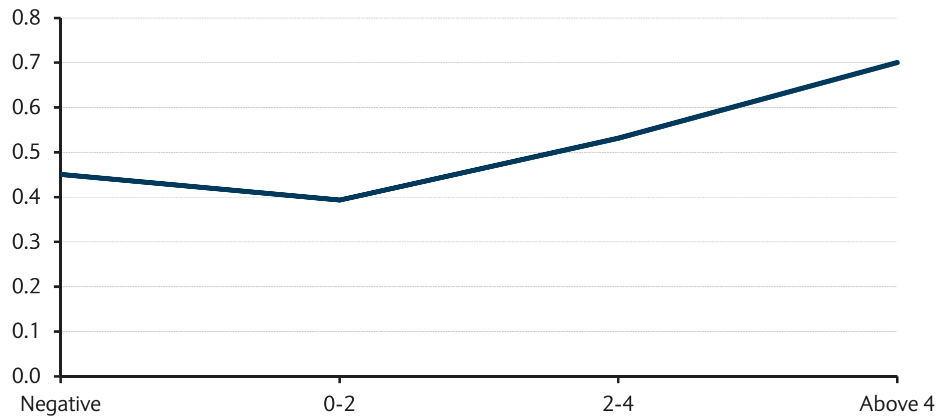
Duration times spread (DTS) is used throughout our risk models as a consistent way to capture volatility associated with credit risk. This approach is used, for instance, in our subprime and CMBS risk models, whereby spread volatility is a linear function of a bond's DTS level. MBS passthrough securities are considered risk-free in general; however, we still observe the presence of high spread volatility in the securities with relatively high DTS (Figure 14). A DTS high spread factor is added to accommodate any potential volatility differential between high and low spread bonds: only the bonds with spread higher than a particular threshold load on it. The loading is:

$$OASD_{i,t} \times \max(0, LOAS_{i,t} - LOAS_t^{High})$$

Both $OASD_{i,t}$ and $LOAS_{i,t}$ are bond specific, while $LOAS_t^{High}$ is the threshold level. Typically, 10% of the sample hits this threshold. High spread risk is responsive to the market credit environment change and can be a critical factor in financial turmoil episodes. This factor also helps in correcting for the high idiosyncratic volatilities found in the current model.

FIGURE 14

**Volatility of Other Spread Return (%/month) by DTS (Yr*%)**




Source: Barclays Research

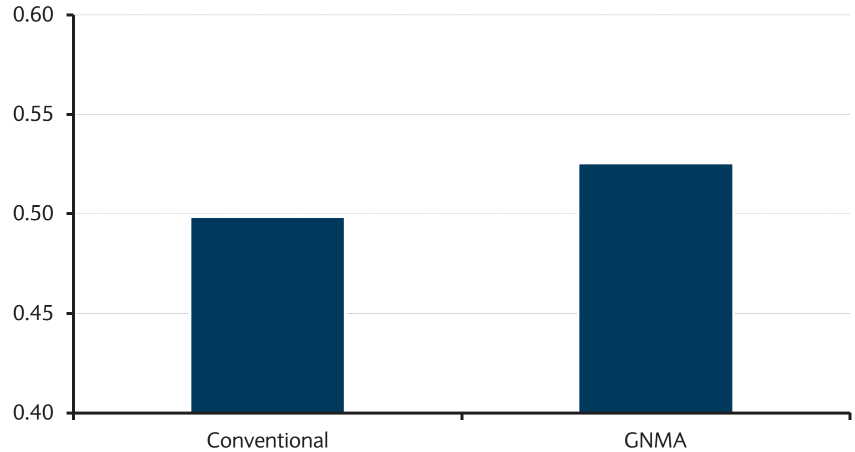
Our research also suggests that bond issuer and loan term affects the return volatility more through the discount factor rather than prepayment deviations. Therefore, these factors are also grouped under the “other spread risk” component.

- Spread GNMA and Spread Non-30 year

We observe different cross-section behaviour of the MBS spread returns across program type and term (Figure 15 and Figure 16). Specifically, GNMA and 30y term securities show higher historical spread return volatilities. Two factors, “GNMA” and “non-30 year” are added to accommodate these differences. The loadings are $OASD_{i,t} \times I_{i,t}^{GNMA}$ and $OASD_{i,t} \times I_{i,t}^{Non30yr}$, where $I_{i,t}^{GNMA}$ and $I_{i,t}^{Non30yr}$ are indicator dummies.

FIGURE 15

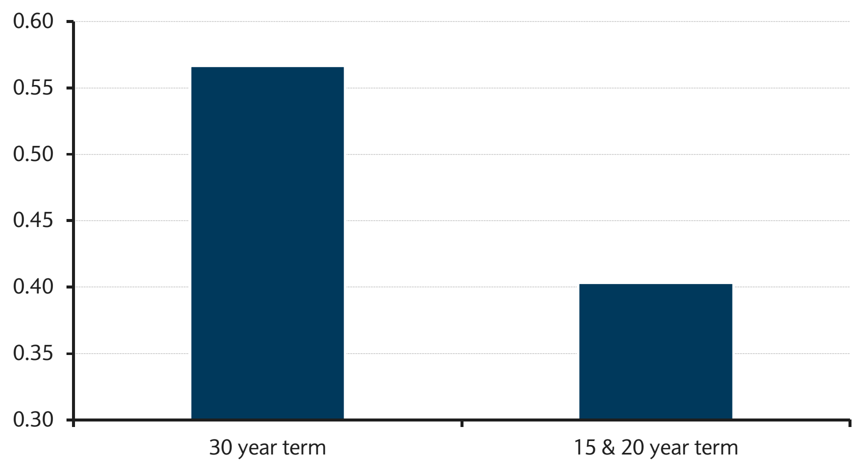
**Volatility of Other Spread Return (%/month) by Program Type**




Source: Barclays Research

FIGURE 16

**Volatility of Other Spread Return (%/month) by Term**




Source: Barclays Research

**Systematic Risk – Summary**

In summary, our factor model can be represented as:

$$
\begin{aligned}
R_{i,t+1}^{Stochatic} = & \sum_{K=1}^{6} KRD_{i,t}^{K} \times F_{t+1}^{YC,K} + OAC_{i,t} \times F_{t+1}^{OAC} + \sum_{K=1}^{6} SSD_{i,t}^{K} \times F_{t+1}^{SS,K} \\
& + VolDur_{i,t} \times (L_{i,t}^{Short} \times F_{t+1}^{ShortVol} + L_{i,t}^{Long} \times F_{t+1}^{LongVol}) \\
& + PrepayDur_{i,t} \times \left[ (RI_{i,t} - RI_{t}^{MIN}) F_{t+1}^{RI} + (SATO_{i,t} - SATO_{t}^{MIN}) F_{t+1}^{SATO} \right] \\
& + OASD_{i,t} \times \begin{bmatrix} F_{t+1}^{UHG} + \max(0, LOAS_{i,t} - LOAS_{t}^{High}) F_{t+1}^{DTS} \\ + I_{i,t}^{GNMA} F_{t+1}^{GNMA} + I_{i,t}^{Non30yr} F_{t+1}^{Non30y} \end{bmatrix} \\
& + \varepsilon_{i,t+1}
\end{aligned}
$$

The model consists of 13 curve factors, 2 estimated volatility factors, 2 prepayment factors and 4 spread factors, for a total of 21 factors. Note that the curve factors are observed and common to all fixed income securities. All the other factors are estimated and specific to the MBS fixed rate market.

**Regression Results**

Once all the loadings are identified, we are ready to estimate our risk factors through robust monthly regressions. In particular, we regress the cross-sectional spread returns over the month against the set of prepayment deviation and other spread factor loadings as of the beginning of the month. The monthly realizations of the risk factors are aggregated into a panel database on which we build our covariance estimation[6].

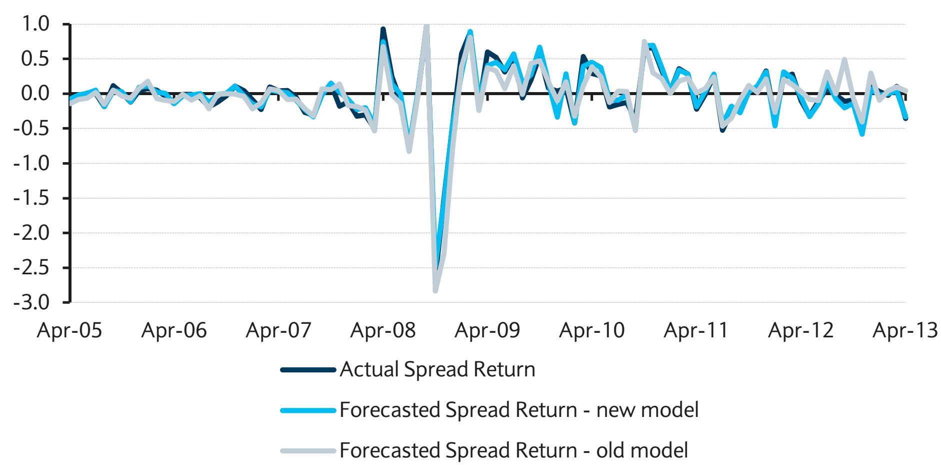
For in-sample analysis, we look at the quality of the model using many measures, namely fit plots, goodness of the fit, the portion of idio variance over total variance and the correlation of the regression residuals (idio correlation). In what follows we review some of this evidence.

First, we display the actual monthly spread returns for the index versus the model's projected systematic spread return (Figure 17). Projected systematic spread returns are computed by multiplying the loadings of the index in the beginning of the month by the estimated factor realizations for that month. Figure 17 shows that the forecasted spread return in the new model tracks actual returns closer than the current model. This suggests that the new model presents factors that better explain the actual returns for the index. This is particularly true for the most recent period of analysis.

Figure 18 shows, for each month, the standard deviation of the actual spread returns and of the projected systematic spread returns in the cross section. Systematic spread return volatility is the standard deviation of the project systematic spread return across all securities in the index for that month. The figure shows that the forecasted spread volatility in the new model accounts for more of the actual spread volatility, when compared with the current model. This seems to suggest that the new factor design allows for a broader distinction of securities in the cross section. Moreover, note that the unaccounted volatility will be mostly captured by idiosyncratic volatility. As we will show later, this evidence suggests that the importance of this source of risk is reduced in the new model significantly, a goal we set to achieve when reviewing the current model.

FIGURE 17

**Actual vs Forecasted Spread Return (%/month)**

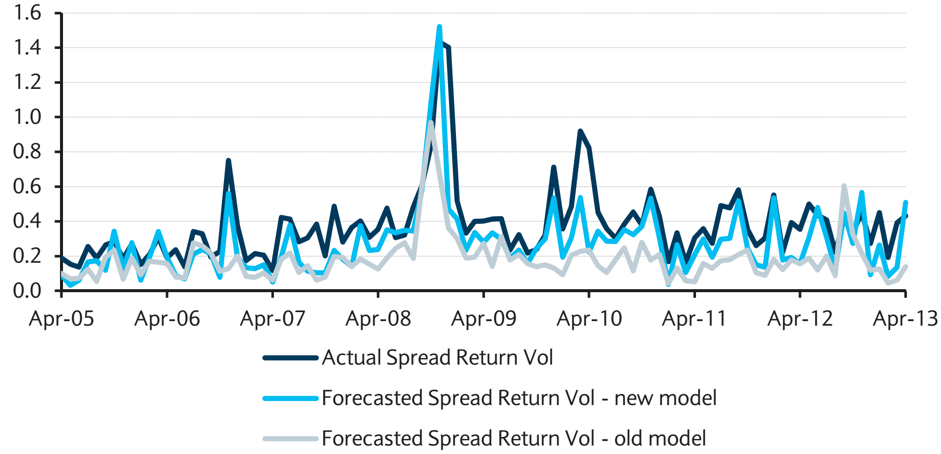



Source: Barclays Research

[6] Please refer to *VOLATILITY FORECASTING A Unified Approach to Building, Estimating, and Testing Models*

FIGURE 18

**Actual vs Forecasted Spread Return Volatility (%/month)**




Source: Barclays Research

One other useful metric for evaluating the model is to analyze the R-squared of the new model. This measure describes the percentage of the total variance of returns that is explained by the systematic factors used. The average R-square across all monthly robust regression for the new model is about 0.56. It is important to understand that this metric is imperfect, especially when evaluating forecasting models. The more variables added to the model, the higher the R-square. Therefore, to avoid over-fitting the model – with the subsequent bad out-of-sample performance – one cannot target the maximization of this number when evaluating a forecasting model. In fact, we tested several versions of this model that delivered higher R-squares, but that failed other important tests we use to evaluate the model (e.g., colinearity tests). The value of 0.56 for security level monthly spread returns is a very satisfactory one and compares well with numbers from other asset classes.

One concern raised by the current model was the significant relative size of idiosyncratic risk, even for well diversified portfolios. This high level suggests the deterioration of the current model's systematic factors in explaining cross-sectional returns. Figure 19 shows that the new model significantly improves this situation. Specifically, for all panel data, we compute the average ratio of the idiosyncratic return variance to total return variance. This ratio is at about 20% for the current model, but is reduced significantly to 3.8% in the new model. This reduction indicates that the systematic risk now explains a significantly larger portion of the total return and return variance. In the following section, we detail our model for idiosyncratic volatility forecast. Before doing so, we analyze evidence regarding residual return correlation.

FIGURE 19

**Idiosyncratic Variance vs Total Variance**

| | Idiosyncratic Variance /Total Return Variance |
|---|---|
| New Model | 3.80% |
| Current Model | 20% |

Source: Barclays Research

A side effect of the analysis above – high idiosyncratic risk and lower ability of the systematic factors to characterize current cross section return dispersion in the current model – manifests itself in the correlation of the actual idiosyncratic returns. Figure 20 exhibits this statistic for both models. Idiosyncratic return correlation reduces significantly in the new model, from 23.5% to 2.4%. A more granular analysis shows that the improvements are broad, across coupon, issuer, SATO and DTS buckets. The highest idiosyncratic correlation for the new model is at 14% for bonds with the same coupon. This number compares with 52% in the current model and comes mainly from very high coupon bonds that are now a very small part of the universe.

Given that idiosyncratic variance accounts for less than 4% of the total return variance in the new model and that the correlation of this idiosyncratic risk is significantly muted too, we decide not to rely on any idiosyncratic correlation model in the new setting. This allows us to eliminate the complex correlation model currently in place, significantly simplifying the analysis.

FIGURE 20

**Idiosyncratic Correlation**

| Idio Correlation | Overall | Coupon | Issuer | SATO | DTS buckets |
|---|---|---|---|---|---|
| New Model | 2.4% | 14% | 9% | 7% | 7% |
| Current Model | 23.5% | 52% | 26% | 33% | 34% |

Source: Barclays Research

### *The Idiosyncratic Risk Model*

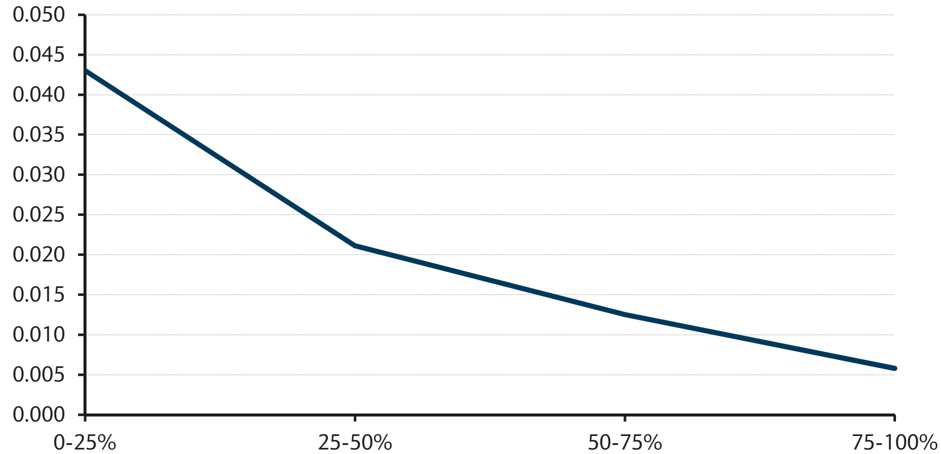
The idiosyncratic return of a bond is the part of its return that is not captured by the systematic factors. An intuitive forecast for the volatility of the idiosyncratic return is its historical volatility. However, this approach does not work so well for generic fixed income securities, as the characteristics of the bond may change significantly through time. Instead, we model this forecast based on some characteristics of the bond, and taking into account how the idiosyncratic return is related historically with those characteristics. Specifically, in our new model, the idiosyncratic variance of MBS securities is driven by its spread duration, outstanding balance and prepayment duration:

$$Var(\varepsilon_{i,t+1}) = OASD_{i,t}^2 \times (\theta_{t+1}^{Spread} + Balance_{i,t} \times \theta_{t+1}^{Balance}) + PrepayDur_{i,t}^2 \times \theta_{t+1}^{Prepay}$$

in which $\theta_{t+1}^{Spread}$, $\theta_{t+1}^{Balance}$ and $\theta_{t+1}^{Prepay}$ are the idio parameters estimated monthly using robust regression. Each month, we estimate the idiosyncratic parameters using the residuals coming from the systematic factor regression. To forecast the idiosyncratic risk over the next month, we average the historical parameters and use those averages in the formula above. We currently provide idiosyncratic factors with both an exponentially time weighted average with 1 year half life, and a simple unweighted historical average. Figure 21 presents the evidence of a strong negative correlation between outstanding balance – one of the characteristics to predict idiosyncratic volatility – and idio variance, which is in line with the fact that large deals tend to have lower unexplained returns (due to better liquidity, etc). Similar evidence can be presented for the other characteristics.

FIGURE 21

**Idiosyncratic Variance ( $\%^2$ ) by Outstanding Balance Quartiles**

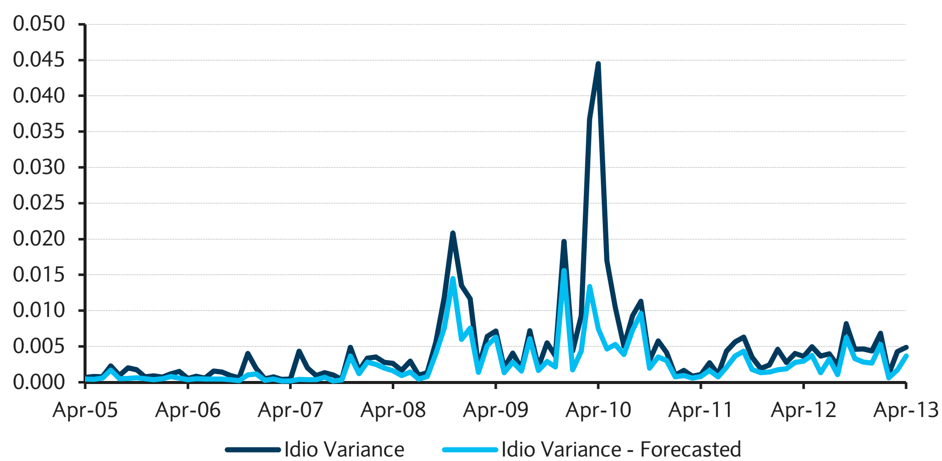



Source: Barclays Research

The structure of the idiosyncratic model can be evaluated in ways similarly as the systematic component of the model. Figure 22 illustrates the in-sample fit chart of the regression (in parallel to Figure 18). We can see that the new model does a good job in forecasting the cross section diversity of idiosyncratic returns, especially for recent time periods. We can also report that the average R-square for the new idiosyncratic component is about 0.82 (through robust regression). In short, the very parsimonious new idiosyncratic model seems to do a good job in describing both the size and the diversity of idiosyncratic return variance.

FIGURE 22

**Actual vs Forecasted Idiosyncratic Variance ( $\%^2$ )**



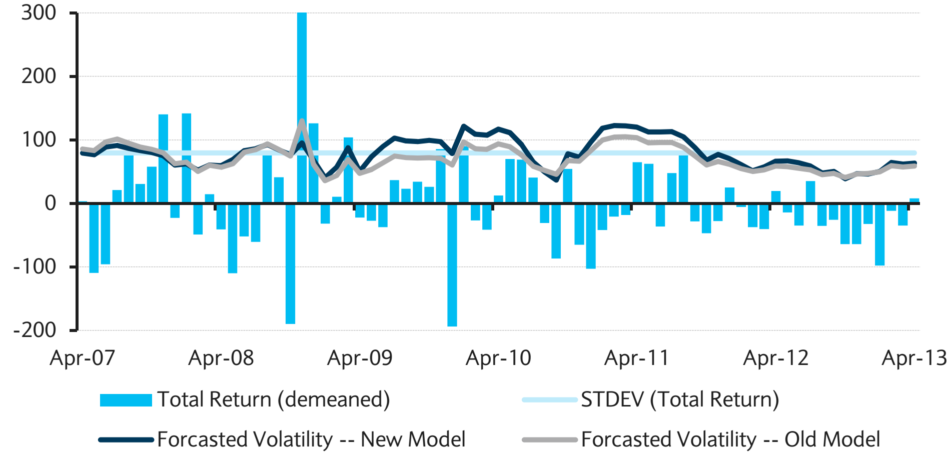

Source: Barclays Research

## Backtesting the MBS Fixed Rate Index

Given our limited time-series sample, we cannot perform exhaustive out-of-sample tests for the new model spanning multiple market conditions. Because the calibration of the model starts only in 2005 and we need a training period to calculate the covariance matrix, we investigate the out-of sample behaviour of the model over the 2007-2013 period (74 months). In terms of the total volatility of the US MBS Fixed Rate index, the new model tracks closely with the current one (Figure 23). It is important to emphasize that the changes to the model were not motivated by poor forecast performance of the model at the index level, as previously referred.

FIGURE 23

**Backtest on US MBS Fixed Rate Index – Time Weighted Forecasted Volatilities (bp)**




Source: Barclays Research

In a backtest, the metric on which we focus is the standard deviation of the standardized return, which is defined as the realized return scaled by (ex-ante) forecasted volatility. Though not perfect, this is probably the most widely used metric in out-of-sample volatility model evaluation. A perfect risk model implies this metric to equal 1. The current model presents a statistic of 1.05, signalling an overall insignificant risk overestimation. The new model slightly improves upon this metric (1.04).

To better assess the aggregate effect of each factor on the overall risk for the MBS index, we report spread factor volatility and factor correlations in Figure 24. We do not observe any alarming correlations among the major spread factors, a feature necessary for a robust forecast. The UHG spread volatility factor is negatively correlated with the prepayment factors. This relationship emphasizes some competing explanatory power between prepayment and spread duration. The model is able to discriminate between these two sources of spread risk, but there is still some overlap between the two. The UHG spread factor is also negatively correlated with the non-30 year factor, confirming the evidence that non-30 year bonds tend to be less volatile (Figure 16).

FIGURE 24

Time Weighted Factor Volatility and Correlation as of April, 2013

| | Short Vol | Long Vol | Prepay Refi | Prepay SATO | UHG Spread | High Spread | Spread GNMA | Spread Non -30 year |
|---|---|---|---|---|---|---|---|---|
| Volatility | 209.87 | 218.46 | 154.32 | 333.86 | 2.54 | 31.44 | 2.82 | 2.81 |
| **Factor Correlation** | | | | | | | | |
| Short Vol | 1.00 | 0.84 | 0.00 | 0.00 | 0.01 | (0.00) | (0.00) | (0.01) |
| Long Vol | | 1.00 | 0.00 | 0.00 | 0.01 | (0.01) | (0.00) | (0.01) |
| Prepay Refi | | | 1.00 | (0.07) | (0.25) | (0.40) | (0.05) | (0.08) |
| Prepay SATO | | | | 1.00 | (0.43) | (0.03) | (0.05) | 0.16 |
| UHG Spread | | | | | 1.00 | 0.06 | 0.00 | (0.55) |
| High Spread | | | | | | 1.00 | 0.06 | 0.28 |
| Spread GNMA | | | | | | | 1.00 | (0.05) |
| Spread Non -30 year | | | | | | | | 1.00 |

Source: Barclays Research

To contextualize the analysis, we run the MBS fixed rate index through the new risk model. Figure 25 shows the time-weighted volatility of each factor, its index loading, the percentage of TEV and contribution to TEV. As of April 2013, we have seen that the curve risk clearly dominates the risk composition of the index. To make the analysis more interesting, we can rerun this analysis with the curve and swap spread risk components hedged. Under this setting, the risk of the index is explained by curve volatility risk (60%), prepayment risk (35%) and the other spread risk (5%). The risk associated with volatility reflects the important optionality component embedded in these securities. This risk is not surprising and is constantly monitored and hedged by portfolio managers using the swaptions market. The fact that the "new" component of the model directly associated with prepayment is also an important contributor to risk emphasizes the usefulness of introducing these factors in our new risk model. Note that this risk decomposition can change dramatically over time and for specific portfolios, so we do expect different portfolios to highlight the different parts of the new risk model.

FIGURE 25

Time Weighted Risk Contribution as of April, 2013

| Factor name | Factor Loading | Factor Volatility | Percentage of TEV | Contribution to TEV |
|---|---|---|---|---|
| Curve | | | | |
| USD 6M key rate | 0.14 | 7.92 | 0.53 | 0.30 |
| USD 2Y key rate | 0.76 | 10.71 | 10.43 | 5.81 |
| USD 5Y key rate | 0.91 | 18.70 | 27.23 | 15.18 |
| USD 10Y key rate | 1.20 | 22.63 | 42.08 | 23.46 |
| USD 20Y key rate | 0.77 | 22.94 | 25.04 | 13.96 |
| USD 30Y key rate | 0.11 | 22.67 | 3.16 | 1.76 |
| USD Convexity | (2.72) | 2.58 | (2.98) | (1.66) |
| Swap Spreads | | | | |
| USD 6M swap spread | 0.14 | 8.43 | 0.10 | 0.06 |
| USD 2Y swap spread | 0.78 | 6.97 | 1.16 | 0.65 |
| USD 5Y swap spread | 0.94 | 4.92 | 0.91 | 0.51 |
| USD 10Y swap spread | 1.22 | 5.33 | 0.26 | 0.15 |
| USD 20Y swap spread | 0.78 | 5.37 | (0.16) | (0.09) |
| USD 30Y swap spread | 0.10 | 6.76 | (0.07) | (0.04) |
| MBS Spread & Vol. | | | | |
| Short Volatility | 0.00 | 209.87 | (0.45) | (0.25) |
| Long Volatility | 0.08 | 218.46 | (9.00) | (5.02) |
| Prepay Refi Incentive | 0.08 | 154.32 | 2.06 | 1.15 |
| Prepay SATO | 0.04 | 333.86 | 1.77 | 0.99 |
| Spread | 4.38 | 2.54 | (2.66) | (1.48) |
| High Spread | 0.01 | 31.44 | 0.01 | 0.00 |
| Spread GNMA | 1.28 | 2.82 | 0.40 | 0.22 |
| Spread Non-30 year | 0.50 | 2.81 | 0.15 | 0.08 |

Source: Barclays Research

## Conclusion

Overall, the new model extends the systematic factor space by incorporating more risk sources related to the prepayment and spread components of the risk of these securities. It better utilizes the outputs from the Barclays Prepayment model and improves over the current model with several aspects. First, it rules out the potential for stale factors with all factors defined either on a continuous basis or dynamically with market shifts. Second, by capturing more return volatility through systematic factors, we manage to significantly reduce the idiosyncratic correlation so that extra idiosyncratic return correlation modelling is unnecessary. Coinciding with that is a much smaller idiosyncratic volatility as a percentage of overall volatility. This result is in line with the fact that fixed rate agency MBS instruments are, broadly speaking, quite homogeneous. Lastly, the backtest on MBS Fixed Rate index has shown strong performance over the last six years.

## Appendix: A Brief Review of the Current Model

The current risk model for fixed rate MBS securities was developed in early 2000s. Following the linear factor model framework, the stochastic return was decomposed into a systematic component and an idiosyncratic component. Besides the regular curve factors and swap spread factors that is common to all fixed income securities, there are 14 additional systematic factors to capture the spread risks: short and long volatilities, 15y and 30y mortgage spreads, new discount, new current, new premium, seasoned discount, seasoned current, seasoned premium, GNMA 30y, CONV 15y, GNMA 15y and CONV Balloon. In formula, the stochastic return is split into five main components plus an idiosyncratic residual:

$$R_{i,t+1}^{Stochastic} = R_{i,t+1}^{Tsy} + R_{i,t+1}^{SS} + R_{i,t+1}^{Vol} + R_{i,t+1}^{MtgRate} + R_{i,t+1}^{Spread} + \varepsilon_{i,t+1}$$

The approach to model the Treasury curve, swap spread and curve volatility risks has been carried over to the new risk model and was discussed in the main section of the paper. Therefore, we briefly review the other two components in the following sections.

## Mortgage Rate Spread Risk

The current-coupon mortgage rate spread, defined by the vol-adjusted spread of a current coupon mortgage rate to a blend of the swap and Treasury curve, is an important determinant of the refinancing incentive and expected cash flows of a MBS security. The corresponding return is modeled as:

$$R_{i,t+1}^{MtgRate} = MtgRtDur_{i,t} \times (L_{i,t}^{30yr} \times F_{t+1}^{Mtg30yr} + L_{i,t}^{15yr} \times F_{t+1}^{Mtg15yr})$$

Where $MtgRtDur_{i,t}$ is the measure of price sensitivity to mortgage rate spread shifts. $L_{i,t}^{30yr}$ and $L_{i,t}^{15yr}$ are indicator dummies for 30y term and 15y term. Their associated factors are observed changes in the corresponding current coupon bonds' LOAS. Mortgage rate risk is supposed to capture most prepayment risk related to rate refinance of the bond. However, more recently, we find insignificant correlation between prepay deviation volatility and mortgage rate spread duration. We therefore discontinue these factors in the new model, and use more direct prepayment risk measures that are now available to us, such as prepayment duration. As described in the paper, these co-move better with prepayment deviations volatility.

## Other Spread Risk

The spread return factor model in the current implementation is constructed along a few dimensions of the characteristics, based on the conception that the MBS market is comprised of relatively homogeneous securities defined by program, price tier, and WALA.

$$R_{i,t+1}^{Spread} = OASD_{i,t} \times [\sum_{K=1}^{10} L_{i,t}^{K}(price_{i,t}, wala_{i,t}, program_{i,t}) \times F_{t+1}^{K}]$$

Specifically, three price tiers (96, 100 and 104 dollars) and two WALA tiers (18 and 48 months) are selected, with linear interpolation (ramp function) used between and across these points. These two sets of loadings are cross-multiplied to generate six price-wala loadings: New Discount, New Current, New Premium, Seasoned Discount, Seasoned Current and Seasoned Premium. A bond's price and wala loadings sum up to 1 each.

In addition, CONV 30y is treated as the base program; any security in the other four programs (GNMA 30y, CONV 15y, GNMA 15y and CONV Balloon) has a loading of 1 on the corresponding program factor.

## Idiosyncratic Risk

Idiosyncratic return is the residual return net of all systematic returns. In the current model, we have found average 23.5% of correlation between any two generic bonds and 52% between two generics with the same coupon (Figure 20). The current model partitions the securities into seven buckets according to issuer, coupon and maturity, then builds a complex idio correlation model for each of the bucket. This model is also retired in the new model: a better characterization of the systematic component of returns makes it obsolete.

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