WHITE PAPER

DURATION & BETA METHODOLOGY PERFORMANCE

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BACKGROUND

Pipeline risk management is a critical component for mortgage originators. Movements in interest rates can significantly change the value of the prospective loans. To hedge the interest rate risk, we need to understand what instrument to use for coverage and how much coverage to apply. The best hedge will be an asset that is similar to the prospective loan, usually a best execution into TBA with similar weighted average coupon and expiration month. But in some cases that might not be practical, and a cross hedge might be used. For the purpose of this paper, we analyze the formation of a hedge ratio from a duration metric or beta (price relationship) metric. This paper explores both concepts to evaluate performance on each respective methodology.

METHODOLOGIES

Optimal Blue Beta Derivation

Optimal Blue uses a beta derived from covariance/variance relationship as the foundation for a hedge ratio. The variables in the beta are two distinct securities. Using a look-back period of 60 days, every individual security is regressed against every other security to estimate how one will move in relation to another. In order to come up with the individual data points for each security, Optimal Blue takes an hourly average of prices within each hour and then calculates the percentage change in those prices. The resulting coefficient, or "beta," can be interpreted as an expected percentage change in one security when another security increases by some percentage.

Given the number of possible combinations of securities, Optimal Blue calculates over 25,000 betas on any given day. In order to present this information in a usable format, Optimal Blue aggregates the betas in such a way that any beta presented in the system is the sensitivity of a given instrument relative to a weighted average market index of loans in the respective pipeline. In essence, the market index captures a client's coupon stack sensitivity. Chart 1 is an example output beta for three different settlement months of a FHLMC 30-year 3% coupon

that is produced in our system. The beta for the March security can be interpreted as follows: If a client's entire pipeline were to experience a 1% increase in price, we would expect this coupon to increase by 1.186%.

Chart 1: Sample Beta for Product, Coupon and Settlement

Position Details

Expand | Collapse

Instrument	Settlement Month	Loan Amount	Coverage	Modeled Loan Amount	Modeled Coverage	Beta	Net Position
FHLMC 15Yr		13,558,343	13,000,000	0	0		507,904
FHLMC 30YR		142,593,905	144,600,000	0	0		-3,052,385
3.0% Total		66,864,878	71,500,000	0	0		-6,052,884
3.0%	Feb	34,661,796	6,700,000	0	0	1.166	32,592,363
3.0%	Mar	31,928,962	64,800,000	0	0	1.186	-38,970,230
3.0%	Apr	274,120	0	0	0	1.186	324,983
3.5% Total		71,306,207	67,600,000	0	0		3,576,080
4.0% Total		4,422,820	5,500,000	0	0		-575,581
FNMA 15YR		787,500	0	0	0		537,656
FNMA 30YR		1,371,922	4,300,000	0	0		-2,915,715
GNMAII 30YR		50,943,217	63,250,000	0	0		-13,936,546
GNMAI 30YR		13,928,422	0	0	0		14,500,889
GNMAII 15YR		423,060	0	0	0		240,011
FHLMC 20Yr		7,243,828	0	0	0		8,465,865

Durations Methodologies

Duration is a measurement of an instrument's sensitivity to interest rate changes. There are several common ways to calculate duration. For this paper, we selected Bloomberg's modified duration, effective duration and option-adjusted duration. Appendix A provides Bloomberg's definition for the respective measurements. The duration methodology attempts to derive future price movements from historical prepayment behaviors. Optimal Blue's beta is based on the historical prices, and is considered a "backward-looking" methodology as opposed to a "forward-looking" duration methodology. Both have their advantages and disadvantages. For example, forward-looking methodologies may not always result in accurate predictions and backward-looking methodologies may become less accurate in extreme market shifts.

PERFORMANCE ANALYSIS APPROACH

To evaluate the strengths and weaknesses of these methodologies, we analyzed performance by comparing the Optimal Blue beta ("OB_Beta") to the three different Bloomberg duration methodologies: modified duration ("Mod_Dur"), effective duration ("Eff_Dur") and option-adjusted duration ("OAD").

The performance analysis included a sample cross hedge of FNCL 3.5 security versus an FNCL 4.0 security. The back test was conducted for the time period 2013 through 2014. Additionally, this included periods of high volatility and low volatility as well as significant and sustained directional changes in the market. To test the accuracies of each methodology, we determined a predicted value versus an actual value. The predicted value was calculated by applying a factor/ratio to the daily price change of the FNCL 4.0 to determine whether a predicted price change of the FNCL 3.5. Equation (1) derives the predicted value from duration ratios.

Formation of Ratio via Duration

FNCL 3.5 $Mod_{Dur} = 5.66$

FNCL 4.0 $Mod_{Dur} = 4.18$

Ratio (r): FNCL 3.5/FNCL 4.0 = 5.66/4.18 = 1.35

$$(x_{(t+1)} - x_t) * r = \hat{y} \qquad (1)$$

x = FNCL 4.0 security price

ŷ = predicted price change in FNCL 3.5

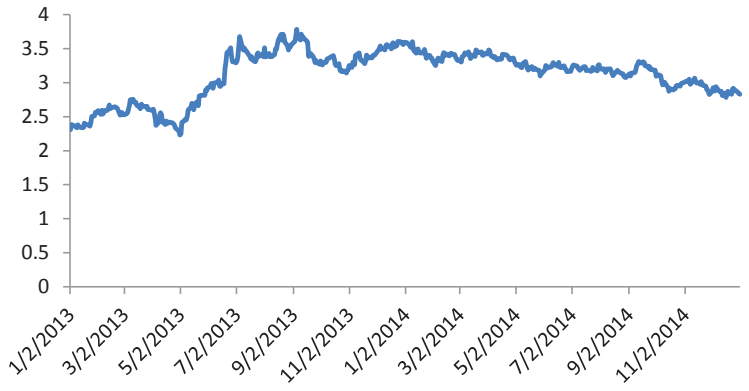
r = methodology ratio (duration ratio or beta)

t = day of observation

RESULTS

The relative performance of the methods is mixed across methodologies. Chart 2 is an illustration of market movement in the current coupon for the time period of the analysis. Please see appendix for current coupon definition.

Chart 2: 2013-2014 FNMA Current Coupon



A measurement of performance reviewed was sum of square errors for the respective methodologies. The sum of square errors penalizes larger errors more than smaller errors, and discloses each methodology on this merit. Below is equation (2) used to determine sum of squared errors.

$$SSE = \sum (y - \hat{y})^2 \qquad (2)$$

y = actual observed FNCL 3.5 price change

$\hat{y}$= estimated FNCL 3.5 price change

Chart 3 displays the sum of square error results by month and year. The Current Coupon Daily Δ represents daily % change of current coupon, an indicator of volatility. The lower sum of squared errors, the better the methodology performed. Performance across methodologies was comparable, and the differences equate to about +/- 0.30% difference in an average model error—no notable outperformer.

Chart 3: Sum of Squared Errors

Date	Current Coupon Daily Δ	OB_ Beta	Mod_Dur	OAD	Eff_Dur
Jan	0.53%	0.14	0.14	0.15	0.19
Feb	-0.05%	0.13	0.14	0.17	0.11
Mar	0.15%	0.10	0.11	0.13	0.11
Apr	-0.59%	0.13	0.13	0.16	0.15
May	1.17%	0.09	0.21	0.41	0.11
Jun	0.65%	0.33	0.25	0.33	0.90
Jul	0.13%	0.17	0.16	0.09	1.70
Aug	0.24%	0.10	0.15	0.06	1.56
Sep	-0.40%	0.10	0.18	0.07	1.64
Oct	-0.11%	0.09	0.10	0.09	0.42
Nov	0.36%	0.14	0.18	0.14	0.93
Dec	0.26%	0.08	0.10	0.09	0.48
2013	**0.19%**	**1.60**	**1.86**	**1.90**	**8.28**
Jan	-0.37%	0.08	0.14	0.06	0.94
Feb	0.03%	0.07	0.12	0.07	0.69
Mar	0.13%	0.05	0.11	0.05	0.75
Apr	-0.15%	0.04	0.11	0.09	0.69
May	-0.25%	0.09	0.10	0.09	0.45
Jun	0.04%	0.06	0.10	0.06	0.76
Jul	0.14%	0.07	0.10	0.07	0.73
Aug	-0.28%	0.05	0.07	0.05	0.66
Sep	0.17%	0.04	0.08	0.05	1.16
Oct	-0.26%	0.10	0.12	0.10	1.48
Nov	-0.32%	0.05	0.05	0.04	0.98
Dec	0.02%	0.11	0.11	0.12	1.71
2014	**-0.09%**	**0.81**	**1.21**	**0.84**	**11.01**

Next, we used cumulative absolute errors to measure the methodologies' performance. Chart 3 (a) clearly illustrates effective duration's underperformance versus the other three methodologies. Effective duration on the FNCL 4.0 security had a pronounced prepayment burnout behavior, as illustrated by the rapid decrease in duration chart 3(b). Additionally, for the time period 2013 through 2014, the OB_Beta slightly outperformed both the Mod_Dur and the OAD methodology on an aggregate level.

Chart 3(a): Cumulative Absolute Error

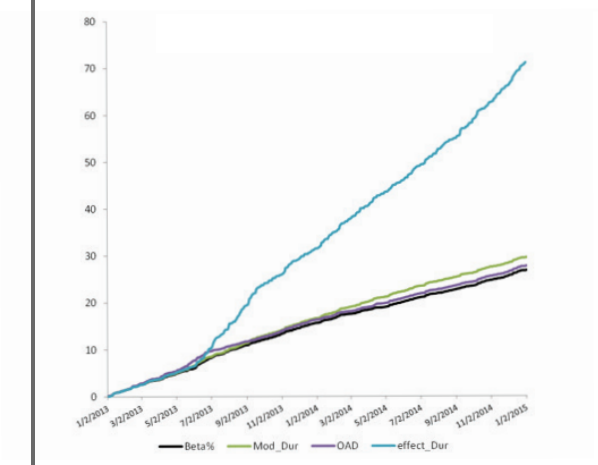
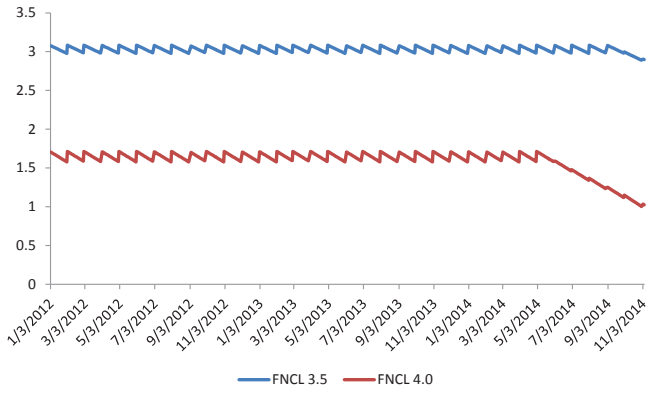


Chart 3(b): Durations

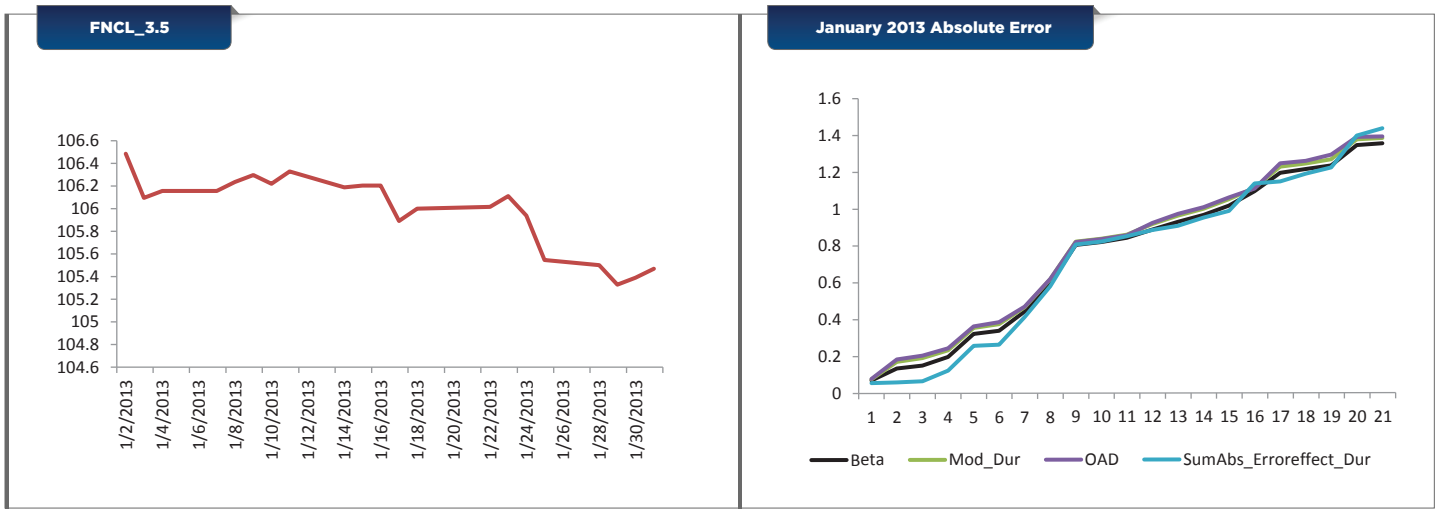


Scenarios

Next, we reviewed how each methodology performed during distinct volatility and market direction scenarios.

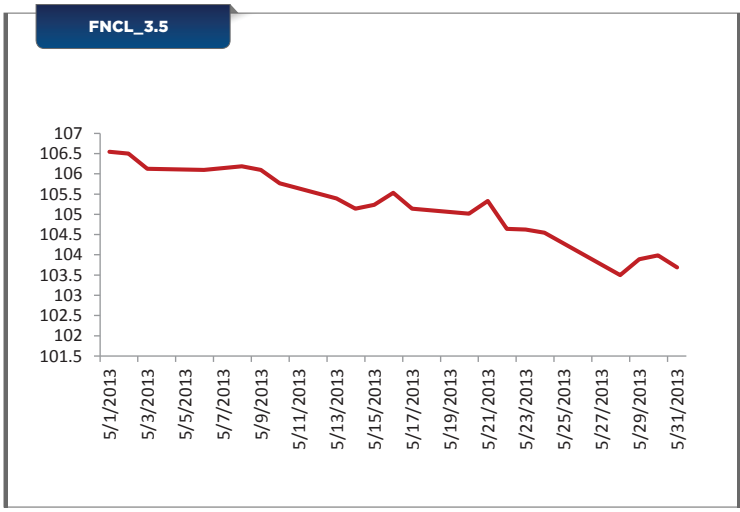
January 2013, May 2013, September 2013 and February 2014 time periods were isolated to review these scenarios. Volatility is defined as the average of current coupon daily percentage changes. Market direction is defined as price increase or decrease of the FNCL 3.5 security.

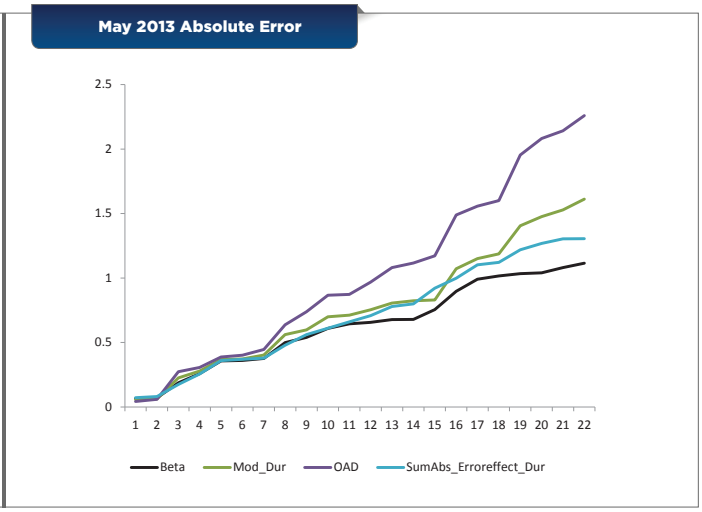
SCENARIO 1:
Market Sell-Off Medium Volatility



- In January 2013 the current coupon average daily change was 0.53%, which surpassed the 2013 average daily change of 0.19%.
- The market declined about 1 point in price during that period.
- The OB-Beta hedge slightly outperformed all of the other models.

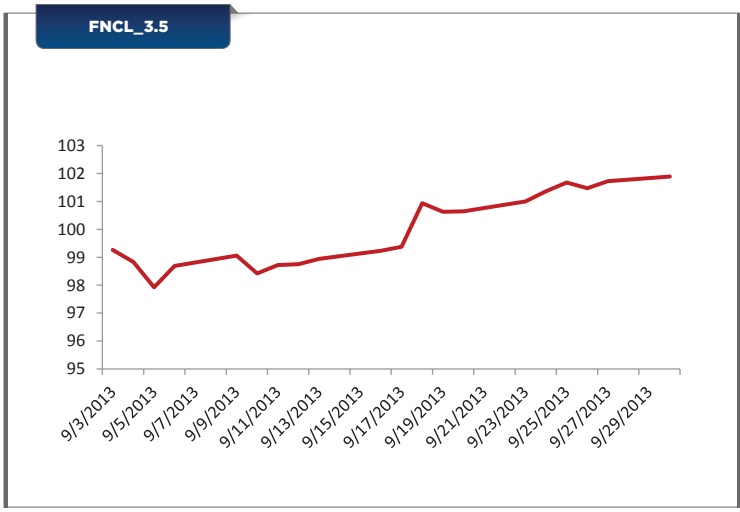
SCENARIO 2:
Market Sell-Off High Volatility

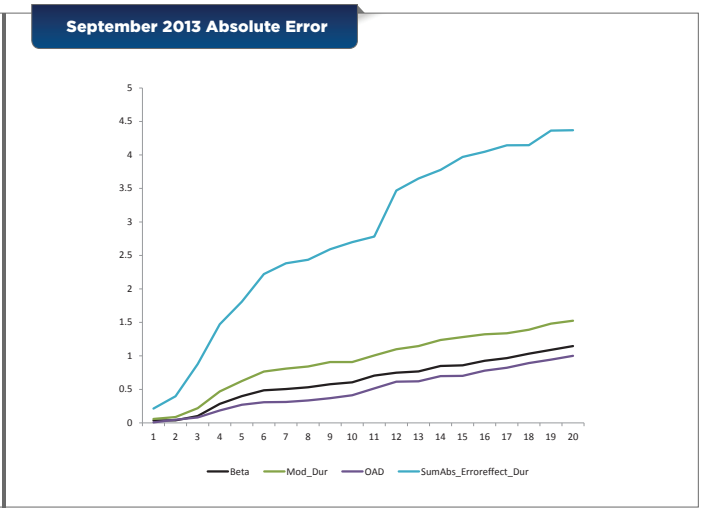




- In May of 2013 the market sold off and volatility was high. The current coupon average daily change was 1.17%.
- Duration hedge ratios broadly underperformed.

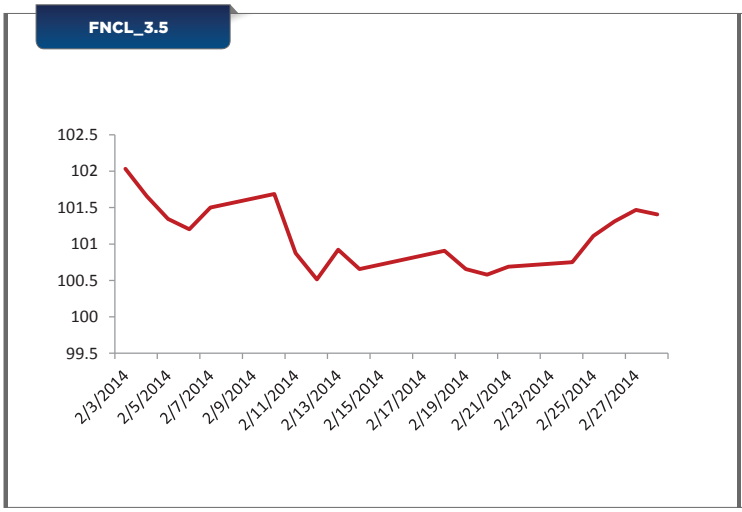
SCENARIO 3:
Market Rally Medium Volatility

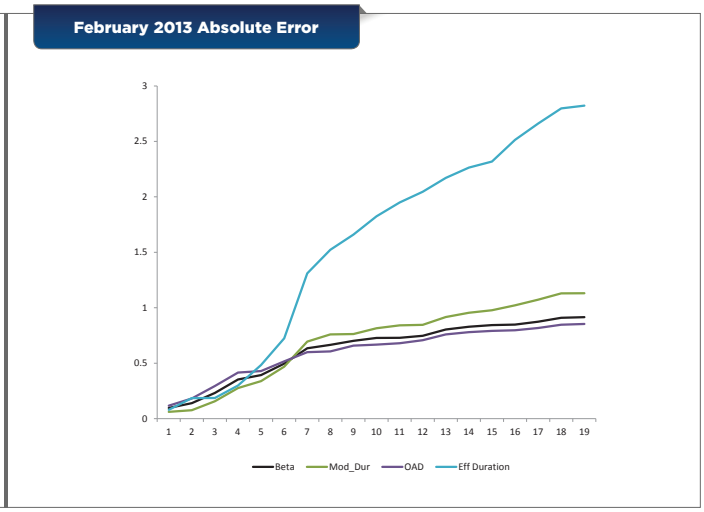




- In September 2013, the market rallied and volatility of the current coupon's average daily percentage change was -0.40%.
- OAD methodology slightly outperformed the OB_Beta and Mod_Dur methodologies.
- The Eff_Dur methodology significantly underperformed against all three other methodologies.

SCENARIO 4:
Market Rally Low Volatility





SCENARIO PERFORMANCE

- In February 2013 the market was flat; volatility of the current coupon was minimal at 0.03%
- Beta hedge ratios outperformed the duration hedge ratios.

SUMMARY

Given these results, along with the underlying definitions and applications, the Optimal Blue beta model should not be thought of as a distinct alternative to duration calculations, but rather as a close relative to durations. Depending on the specific time period and market conditions analyzed, the performance results are mixed. However, for the time period encompassing all of 2013-2014, the Optimal Blue beta methodologies outperformed other methods examined in this paper.

The analysis comes with a caveat on the methodologies used: There are many ways to derive hedge ratios of securities. This paper only examined basic market observed duration calculations. Additionally, performance across varying time lengths and market conditions may have an impact on pipeline performance. These results can be considered preliminary, as various note rates, products and time periods should be considered to determine methodologies' performance. Furthermore, pipeline size, pipeline characteristics and business operations may ultimately determine the best methodology for performance and integration.

Appendix A: Definitions

Macaulay Duration[1]:
The weighted average term to maturity of the cash flows from a bond. The weight of each cash flow is determined by dividing the present value of the cash flow by the price, and is a measure of bond price volatility with respect to interest rates.

Macaulay duration can be calculated by:

where

$$\text{Macaulay Duration} = \frac{\left[\sum_{t=1}^{n} \frac{t * C}{(1+y)^t}\right] + \frac{n * M}{(1+y)^n}}{(\text{Current Bond Price})},$$

t = respective time period
C = periodic coupon payment
y = periodic yield
n = total number of periods
M = maturity value

Modified Duration[2]:
The percentage price change of a security for a given change in yield. The higher the modified duration of a security, the higher its risk.

where

$$\text{Modified Duration} = \frac{\text{Macaulay Duration}}{\left\{1 + \frac{IRR}{M}\right\}},$$

IRR = the internal rate of return
M = the number of compounding periods per year

Option Adjusted Duration (OAD)[3]:
OAD is a methodology using option pricing techniques to value the embedded options risk component of a bond's total spread. Embedded options are call, put or sink features of bonds.

Effective Duration[4]:
A duration calculation for bonds with embedded options. Effective duration takes into account that expected cash flows will fluctuate as interest rates change.

Current Coupon[5]:
The to-be-announced (TBA) mortgage security of any issue for the current delivery month that is trading closest to, but not exceeding, par value. TBA mortgage securities with the current coupon are used as a benchmark throughout the industry to price and value mortgages.

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[1] Bloomberg
[2] Bloomberg
[3] Bloomberg
[4] Bloomberg
[5] Bloomberg