Quantitative Perspectives

REVISITING MORTGAGE CURRENT COUPON: HOW IS THE REGRESSION APPROACH DOING?

by Eknath Belbase | **May 2013**

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Introduction

The AD&Co approach to modeling current coupon uses paths of two- and 10-year par-coupon swap rates as input and outputs a path of the same length of mortgage current coupon. The calculation is based on a linear regression where the intercept term is not estimated; rather the most recent month's spread (calculated as the difference between actual mortgage current coupon and the blended 2/10 level of swaps) is used as the estimate of the spread going forward for the entirety of the forecast vector. The regression parameters were estimated using a modified Hildreth-Liu method, which accounts for the autocorrelation in the regression errors.

We can break down the model specification into the following steps for the purposes of our subsequent evaluation:

1. Treasury vs Libor-Swap
2. Use of two swap curve points rather than one or more than two points
3. Choice of two-year and 10-year versus some other set of two points
4. Requirement that the parameters add up to 1
5. Use of a constant spread approach

Each of these choices will be addressed. In addition, taking this statistical approach presupposes an additional choice:

6. Use of swap-curve points to drive mortgage current coupon in a statistical fashion rather than an intrinsic approach to a direct mortgage current coupon lattice.[1]

This choice has advantages and disadvantages that will be discussed in our evaluation.

Our evaluation of this methodology will combine a statistical evaluation of the performance of the parameter estimates that are in use by AD&Co clients, together with a subjective assessment of each of the above choices.

[1]For example, Bhattacharjee, R., and L.S. Hayre, "The Term Structure of Mortgage Rates: Citigroup's MOATS Model," Journal of Fixed Income, March 2006.

Analysis of Conceptual Soundness

We begin with the last choice first, since the remainder of the analysis is conditional on the use of a statistical approach linking some number of yield curve points from some interest rate curve to mortgage current coupon. It appears that the primary reason for this choice is that most prepayment model specifications historically assumed that Monte Carlo would be the valuation approach in use; the majority of valuation systems in use appear to simulate yield curve points, and then produce mortgage current coupon as a function of those points. However, with the advent of backward induction techniques[2] to value mortgage pools, it is possible to generate a lattice of mortgage current coupon rates without necessarily having to introduce other yield curve points.

Outside of the AD&Co OAS system (where it is a user-option), it does not appear that backward induction has displaced the Monte Carlo approach. Therefore, this choice appears to be a practical one based on how prepayment models are used in a range of external valuation systems.

Treasury vs. Libor Basis

In the original paper, the scarcity of Treasuries was cited (in the presence of long-gone Clinton era budget surpluses) as one potential reason for the relative breakdown of the Treasury-mortgage relationship in relation to the swap-mortgage relationship. With the benefit of 13 years of hindsight, we would now add that apart from the link between GNMA and Treasury rates, the primary liabilities of the institutions originating, distributing and carving up mortgages and MBS (which are GSE agency bonds and bank liabilities), are overwhelmingly LIBOR-based or track LIBOR closely; any historical relationship between Treasury and LIBOR that existed prior to the financial crisis was sorely tested. TED spread models that have been widely discussed in the interim show the treasury-LIBOR basis as being much more volatile than the mortgage-LIBOR basis, which is supported by Figure 1.

The data period covered by these graphs is Sept 2000 through Feb 2013. We can see that during the crisis period (when mortgage rates were below 4%) using a Treasury-based model would have resulted in extremely large errors during flight-to-quality periods. These errors would have been larger even than the elevated error levels of the swap-based method during those crisis periods.

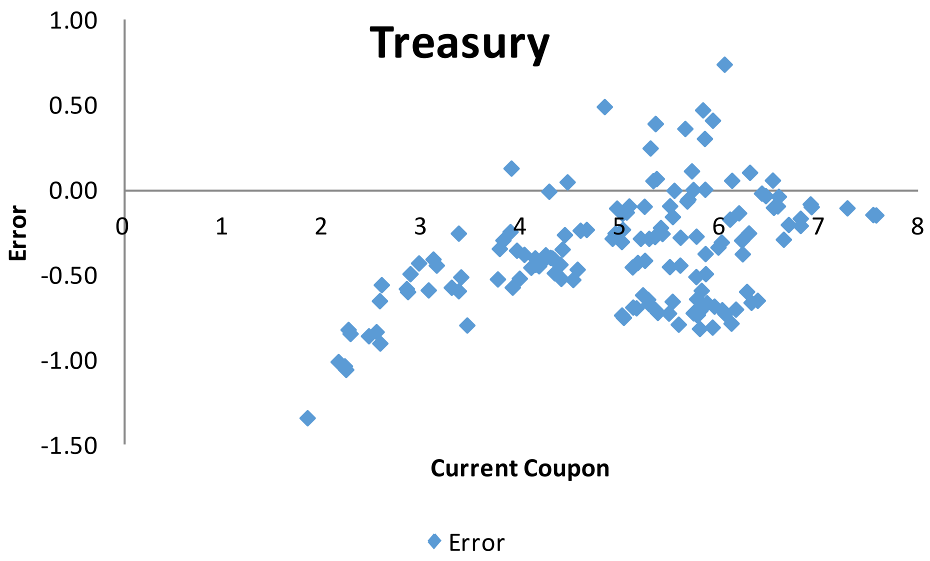
Number of Yield Curve Points Used

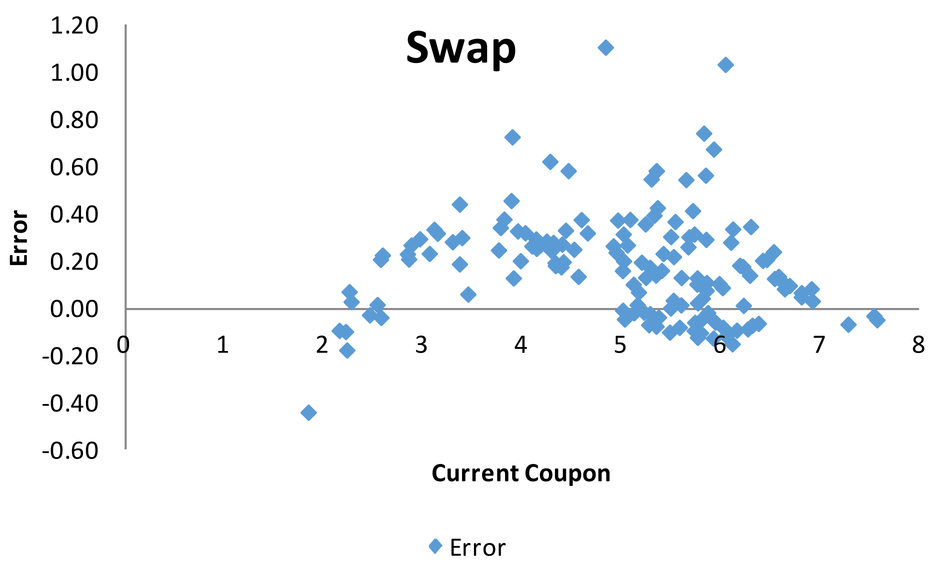
The choice of using a single Treasury point was adequately addressed in the original paper; the reasons for using more than a single point seem obvious. What is less obvious is whether more than two points may be needed. We believe the primary considerations here may again be related to valuation methodologies used by the majority of vendor systems. If it is the case that more than two yield curve points can easily be produced now by most vendor systems, one could argue for an equation with more yield curve points. While the collinearity arising from the use of highly correlated points would need to be dealt with, there may be benefits from the perspective of those users who desire a large number of key-rate durations for hedging purposes.

[2] As in Levin, "Divide & Conquer: Exploring New OAS Horizons, Part I," Quantitative Perspectives, October 2003.

In general, if the number of rate drivers is small in relation to the number of key-rate duration points desired, computed key-rate durations will tend to have an unintuitive saw-toothed pattern.[3]

Figure 1: Out of Sample Errors for Treasury vs Swap Methods





[3]Whether it is necessary to use a large number of key-rate durations for most hedging applications rather than using a principal component-based approach using the first two PCs is a consideration, however, further discussion of this point is somewhat beyond the scope of this article.

Choice of 2s/10s

As we can see in Figures 2 and 3, the 2 and 10 still appear to reasonably represent the majority of the curve.

In particular, for the swap curve, the two-year point has a very high correlation with the three-year and five-year (to the point where including those points in a regression would cause more problems than it would add value), while the 10-year has a similarly high correlation with the seven-year, 15-year, 20-year and 30-year. To be fair, even the two-year and the 10-year have a somewhat high correlation of 0.76.

Figure 2: Treasury Monthly Changes (April 1997–March 2013)–Correlation Matrix

Treas	TB12	TSY02	TSY03	TSY05	TSY10	TSY30
TB12	1.00	**0.89**	0.85	0.72	**0.57**	0.42
TSY02	0.89	**1.00**	0.98	0.91	**0.74**	0.55
TSY03	0.85	**0.98**	1.00	0.95	**0.82**	0.64
TSY05	0.72	**0.91**	0.95	1.00	**0.93**	0.77
TSY10	0.57	**0.74**	0.82	0.93	**1.00**	0.93
TSY30	0.42	**0.55**	0.64	0.77	**0.93**	1.00

Figure 3: Swaps/LIBOR Monthly Changes (April 1997–March 2013)–Correlation Matrix

SWAP	LIBOR 12	LIBOR 24	LIBOR 36	LIBOR 60	LIBOR 84	LIBOR 120	LIBOR 180	LIBOR 240	LIBOR 360
LIBOR 12	1.00	**0.83**	0.75	0.63	0.57	**0.49**	0.43	0.39	0.35
LIBOR 24	0.83	**1.00**	0.97	0.90	0.83	**0.76**	0.70	0.66	0.61
LIBOR 36	0.75	**0.97**	1.00	0.97	0.92	**0.87**	0.81	0.77	0.72
LIBOR 60	0.63	**0.90**	0.97	1.00	0.99	**0.95**	0.91	0.88	0.83
LIBOR 84	0.57	**0.83**	0.92	0.99	1.00	**0.99**	0.96	0.93	0.90
LIBOR 120	0.49	**0.76**	0.87	0.95	0.99	**1.00**	0.99	0.97	0.94
LIBOR 180	0.43	**0.70**	0.81	0.91	0.96	**0.99**	1.00	1.00	0.98
LIBOR 240	0.39	**0.66**	0.77	0.88	0.93	**0.97**	1.00	1.00	0.99
LIBOR 360	0.35	**0.61**	0.72	0.83	0.90	**0.94**	0.98	0.99	1.00

Analysis of Conceptual Soundness (CONTINUED)

Parameters Sum to 1

The primary argument for using a regression constrained to have parameters adding up to one is the desire for parallel shocks to not produce directional jumps in the current coupon spread. This assumption is coupled with the constant spread assumption to some extent as a directional spread is difficult to reconcile with the assumption that a given period's spread is the best guess for the level of future spreads. Additionally, while some directionality can be observed over short time periods, it is challenging to build this in a model used for 30-year periods.

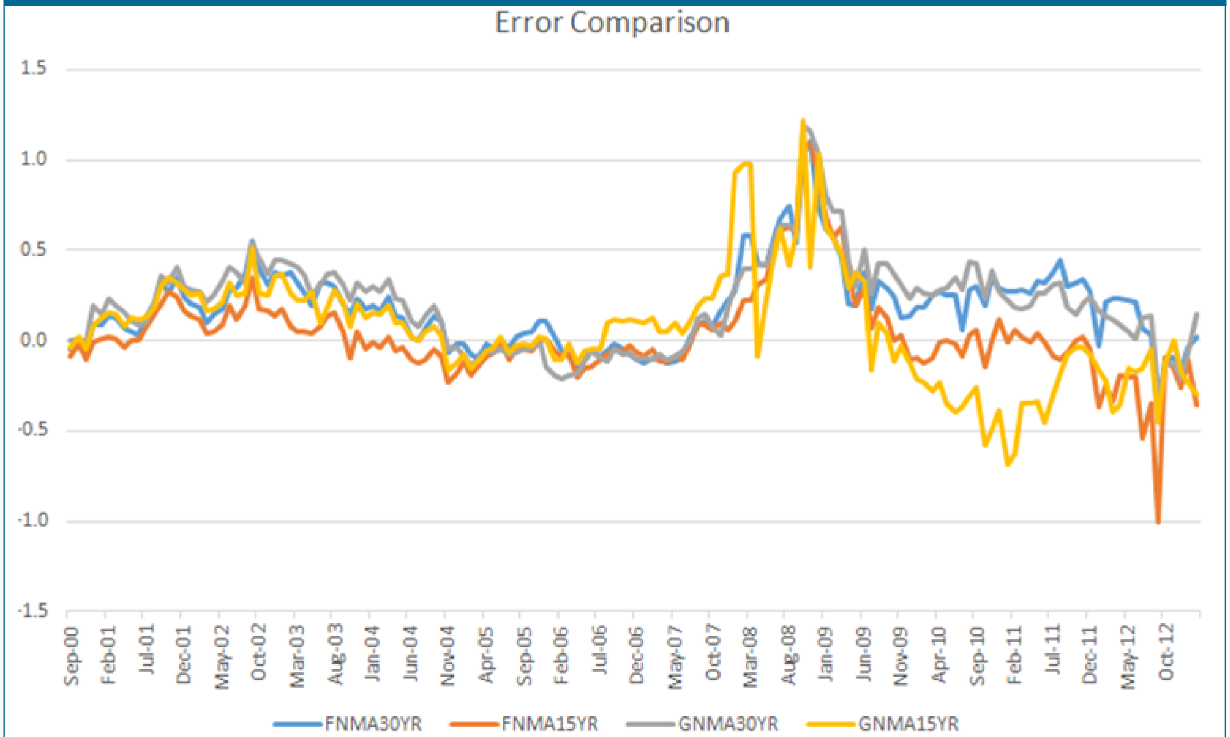
Constant Spread Assumption

The alternatives to the constant spread assumption include some types of directional spread model that depend on some combination or rate levels and the direction/size of rate moves; additionally it is possible to specify models that mean revert the spread at times of elevated mortgage-LIBOR basis. There is a significant compromise in model specification simplicity that occurs by choosing some of these alternate specifications. Because the empirical evidence for the persistence of this directionality is questionable and the ability to specify particular rates of mean reversion from periods of elevated spreads is more of an assumption than something that can be empirically determined, a statistical formulation with these features is probably less preferable. Nevertheless, some alternative specification may need to be considered for periods of abnormally high spread; in addition, for stress testing, it may be worth shocking that spread. We will revisit this assumption in the model limitations discussion at the end of this report.

Analysis of Statistical Performance

In addition to considering the model specification decisions in the prior section, it is useful to look at how the specified model performed out of sample over the intervening period. Figure 4 shows the model error across the 4 major fixed rate product types using the original spread. The relative magnitude of the errors falls into roughly three intuitive periods. There is an initial period of very low model error from the beginning of the out of sample period to about the end of 2007. Then there is an extreme deviation during the crisis period which begins to diminish around March 2009. From that period to date, the errors fall back into the range of the first period, with two exceptions.

Figure 4: Error Time Series for FN30, FN15, GN30 and GN15

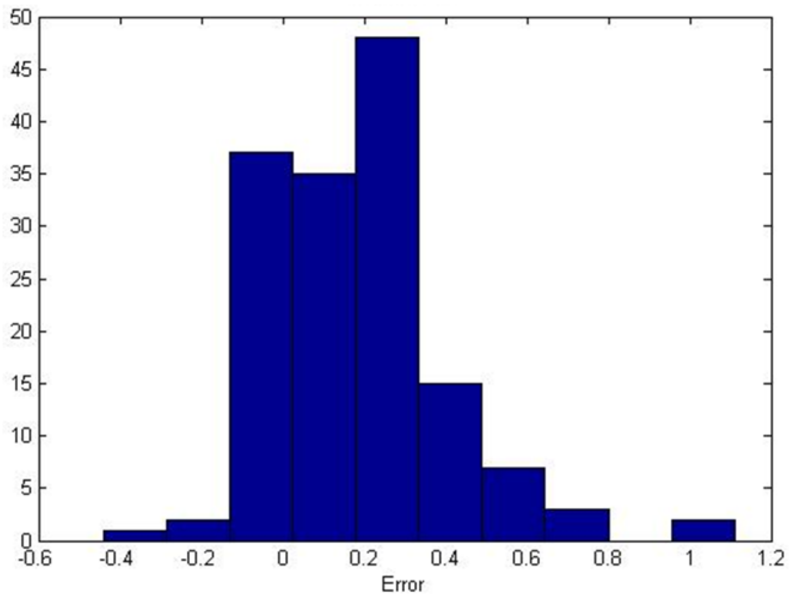


The first exception is the GNMA 15-year in 2010, which seemed to have lower yields than the model predicted (however, past 2010, this model has rejoined the pack). The second is an apparent anomaly in the FNMA 15-year in late 2012. However, that single fluctuation has been traced to a data anomaly based on the Bloomberg current coupon calculation methodology not extrapolating appropriately when the entire coupon stack is at a premium.

Another feature of the error series worth noting is the persistence of error levels. Errors appear to sometimes stay positive or negative for multi-year periods. Individual current coupon errors also have periods where they fluctuate around zero. This behavior is related to the issue of the constant spread assumption imbedded in the regression methodology and in this error analysis. It does appear that for some periods, the actual spreads can remain elevated in relation to the initial spread used (all graphs have been shown using the initial spread from August 2000. This feature may be most problematic when the model is being used in a period of very elevated mortgage-LIBOR basis, as that high spread level would be projected for the entirety of the mortgage product being analyzed. For example, at the beginning of the crisis, the forecast would have been for those elevated levels to persist indefinitely, when in fact they fell back to “normal” in about 15 months.

In the next figure, we look at the histogram of FN30 model errors.

Figure 5: Distribution of Errors for FN30



The mean of the error distribution shown is 18 bps. However, if we break the data into the three historical periods previously discussed, we get 10 bps for the pre-crisis period, 65 bps for the crisis period, and 19 bps for the post-crisis period. Finally, we again note that the methodology used here assumes we never updated our initial spread assumption from 2000. Therefore, the mean of the error distribution being 18 bps is not a sign of bias in the error distribution; rather, the appropriate interpretation under the constant spread specification is that the initial spread used from 2000 was 18 bps lower than the mean spread across all of the mortgage-LIBOR basis environments in the out of sample period.

Figure 6 shows the level of error by level of current coupon for FN30. Similar analysis found no indication of a relationship between size of errors and the level of current coupons.

In Figure 7, we show the level of error for FN30 current coupon against the slope of the curve as measured by the difference between 10s and 2s. The correlation coefficient for the two series is 0.46, showing that a modest linear relationship does exist between the slope of the curve and the overall level of errors (defined in relation to the initial spread from 2000). Our interpretation of this relationship is that adjusting the specification to remove any dependence of error level on slope would produce a flat graph, but the overall variability of errors would remain in the +/- 20 bps natural range observed outside of crisis periods.

Figure 6: Errors by Level of Rates for FN30

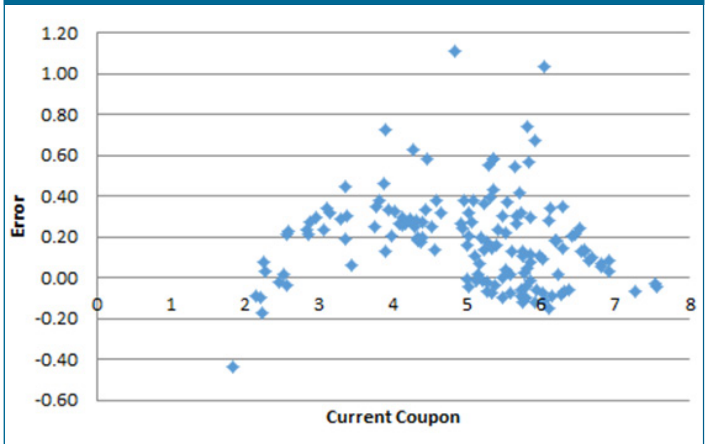
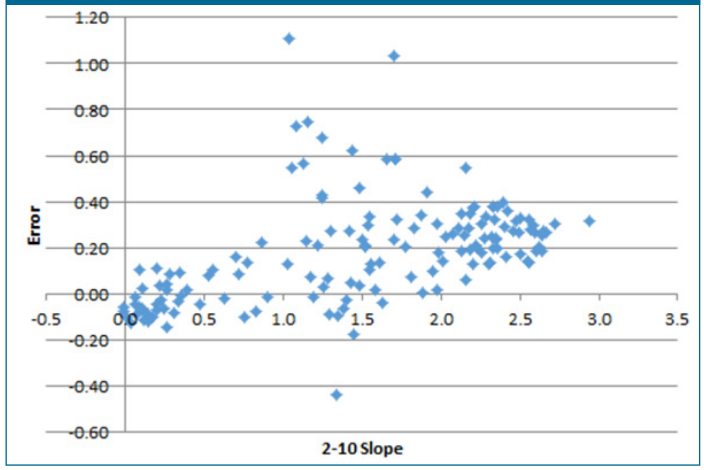


Figure 7: FN30 Errors vs. 2-10s Spread



Parameter Updates

Figure 8: Parameter Estimates Using 2009-13 Data

	LIBOR SWAP Coefficients			
	AGENCY	2 YEAR	10 YEAR	R-Squared
5	FHG	0.282	0.718	86.0%
7	FNMA	0.195	0.805	86.8%
	FHG	0.195	0.805	86.6%
15	FNMA	0.070	0.93	87.7%
	FHG	0.070	0.93	88.3%
	GNMA	unch	unch	unch
30	FNMA	0.071	0.929	90.0%
	FHG	0.060	0.940	90.2%
	GNMA	0.046	0.954	85.9%

In Figure 8, we show the results of re-running exactly the same modified Hildreth-Liu approach as in the original paper[4], using data from 2009 onwards. We excluded the GNMA 15-year due to issues with the data which make the current coupon series unreliable. The two options in such a case are to continue to use existing parameters, or to use a proxy with which to estimate the GNMA 15 coefficients.

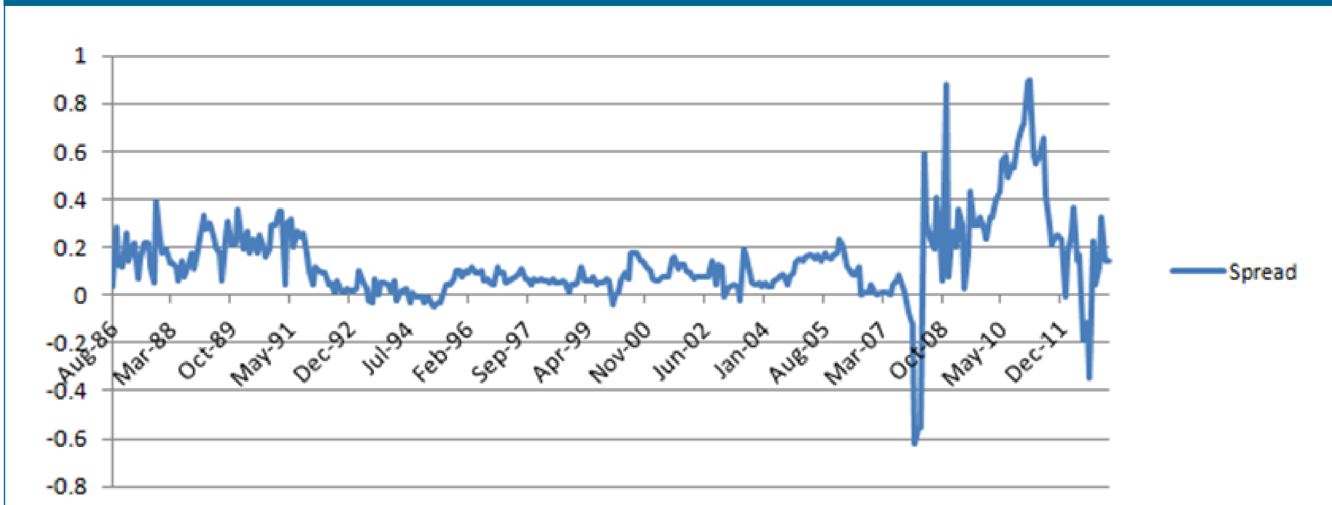
In Figure 9, we show the historical spread between FN15-year rates and GN15s.

After a period in the late 1980s where the spread was in the 10-40 bps range, it appears to have spent all of the 1990s and much of the 2000s in the 0-20 bps range; however, since the crisis the relationship has broken down. We traced the source to the price series for GN15 used to derive current coupon becoming unreliable (with many weeks where reported prices "froze" on adjacent coupons while the rest of the market moved). Only recently has the spread appeared to return to normal (and we have begun publishing our weekly market analysis for GN15s as well). In the absence of reliable data, the two obvious choices are to use the old parameters for GN15s or to over-ride the GNMA parameters with the FN/FG parameters.

[4]See Belbase and Szakallas, *Quantitative Perspectives*. "The Relationship between the Yield Curve and Mortgage Current Coupon". http://www.ad-co.com/qp_library/qpapr01.pdf.

Parameter Updates (CONTINUED)

Figure 9: FN15 to GN15 Spread



Limitations and Future Research

The primary limitation of the current coupon specification which we touched upon earlier appears to be the performance of the constant spread assumption during periods of unusually elevated mortgage-LIBOR basis levels. One direct and flexible approach to address this, while leaving the underlying simplicity of the current specification otherwise intact, would be to allow that initial spread to be adjusted as a vector tuning dial.

The second direction for future research would be to look at adding a slope-related variable, since there does appear to be a relationship between curve slope and the residuals. Finally, we think it is worth looking at non-statistical approaches that allow the dependence on the two- and 10-year points to be spread out among a higher number of points for "better" key-rate duration computation.

One major consideration underlying all of these relationships is the manner in which data from the crisis and post-crisis periods can be used. During the crisis, spreads were elevated; post-crisis, the Fed's intervention in the MBS markets has likely tightened spreads relative to market levels that would prevail otherwise.

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