QUANTITATIVE PERSPECTIVES

HOME PRICE & PREPAYMENTS: THE NEW ANDREW DAVIDSON & CO., INC. PREPAYMENT MODEL

By Eknath Belbase, PhD

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ANDREW DAVIDSON & CO., INC.

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Abstract

In this article, we discuss the most recent re-estimation of the Andrew Davidson & Co., Inc. (AD&Co.) fixed rate MBS prepayment model and the addition of the Home Price Appreciation factor. We describe the data, the philosophy behind our modeling approach, and the major factors behind prepayments. We address both changes in old factors and the motivation for and form of the new Home Price Appreciation factor. The new version of our model is v4.3.2.

Introduction

The AD&Co. prepayment model for fixed-rate MBS was last re-estimated in late 1998 using data through 1998 and released in early 1999. We have recently updated the model using an additional two years of recent data and released the updated model in July 2001.

This article will begin by describing our philosophy of prepayment modeling. Next, we describe the data and the existing factors in our model. After describing these factors, we look at the Home Price Appreciation factor. This is a significant new addition to our prepayment model, which reflects a shift in our understanding of the underlying economic drivers of prepayments. This factor explains a great deal of variability in prepayment speeds for cusp coupons over time. Finally, we analyze valuation results and discuss some software implementation issues.

Prepayment modeling at the pool level is a mixture of science and art. On the one hand, many of the major components of prepayments have been understood for some time, and a variety of statistical techniques exist to model many of the non-linear features of prepayment behavior. On the other hand, there is a great deal of borrower heterogeneity, and the various factors affecting prepayments tend to interact in ways in which standard statistical techniques may be ill-equipped to capture. Borrower behavior changes over time and new factors may appear. Furthermore, many of the forecasts that a good model will have to generate for stress testing and OAS will be for combinations of factors that have never been observed in history.

Two extreme responses to this mixture of stability and flux are possible. One is to not rely on statistical methodology and build a model that is intuitive, simple and fast, and never re-estimate it as the world changes. The other is to have an extremely complex statistical model that is re-estimated frequently to correct for each instance of actual monthly prepayment speeds differing from model predictions.

At AD&Co. we believe that the optimal response is to take the best features of these polar viewpoints. The first response is not sufficiently empirical. The resulting model, while robust (by definition), may never be accurate; even if accurate to begin with, as dynamics change, it will not keep up with reality.

The second approach is overly technical, and while it may result in extremely good fits of the recent past, the over-fitting involved may actually result in worse future performance by over emphasizing ephemeral phenomenon based on insufficient evidence. In addition, too many factors and terms tend to slow down models and lead to inefficient, bulky valuation engines which cannot be tuned effectively.

Our approach emphasizes simplicity, robustness and efficiency while recognizing the importance of both history and forecasting. We have tended to re-fit the model every one to two years and add additional factors only when we believe that there is sufficient evidence to warrant their introduction and when they are likely to remain important. Furthermore, we prefer to add factors where the inputs are deterministic (e.g. age, WAC) or can be simulated effectively using financial theory (e.g. interest rates) rather than factors which may help explain prepayments further, but are themselves impossible to forecast (e.g. GDP growth) accurately.

In addition to using historical data to fit model parameters, we temper the models to perform reasonably across a wide-variety of stress tests and scenarios never observed in history. Finally, we observe the impact of changing prepayment model parameters on valuation and risk measures, such as OAS, effective duration, and convexity, as an additional test of the model.

While the model parameters tend to be updated every one to two years, the factors used to explain prepayments have been extremely robust over time. We apply the same factors to explain prepayments for all collateral types, with different parameter estimates for each collateral type.

The Data

For this analysis, we used pool-level prepayment data with the following variables: age, WAC, balance, origination year and quarter, and prepayment speed over each month from the origination of the pool to July 2000. Table 1 lists the number of records, period covered and origination amount represented by collateral type.

Table 1
Original Years Covered, Number of Records & Total Origination Represented by Collateral Type

Collateral	Origination Yrs	Records	Total Original Balance
FNMA 15	1986Q4 to 2000Q3	13,772	$244 billion
FNMA 30	1985Q4 to 2000Q3	13,497	$550 billion
FHLMC 15	1984Q3 to 2000Q3	60,935	$347 billion
FHLMC 30	1977Q3 to 2000Q3	338,962	$867 billion
GNMA I 15	1982Q4 to 2000Q3	59,499	$66 billion
GNMA I 30	1974Q3 to 2000Q3	300,560	$944 billion
GNMA II 15	1983Q3 to 2000Q3	13,628	$27 billion
GNMA II 30	1969Q4 to 2000Q3	105,322	$148 billion
FNMA 10	1986Q4 to 2000Q3	9,316	$8 billion
FNMA 20	1987Q1 to 2000Q3	12,064	$55 billion
5YR BALLOON	1990Q1 to 2000Q3	12,617	$53 billion
7YR BALLOON	1982Q4 to 2000Q3	30,849	$109 billion
JUMBO 30 YR	1988Q1 to 2000Q2	12,889	$72 billion
JUMBO 15 YR	1988Q1 to 2000Q2	8,815	$6 billion

In addition to collateral performance data, we used monthly mortgage current coupon data from Bloomberg and home price index data provided by Mortgage Risk Assessment Corporation (MRAC). MRAC's HPI is calculated using a repeat sales methodology on a monthly sales database of approximately 52 million properties (see [2] of the Reference Table for more details).

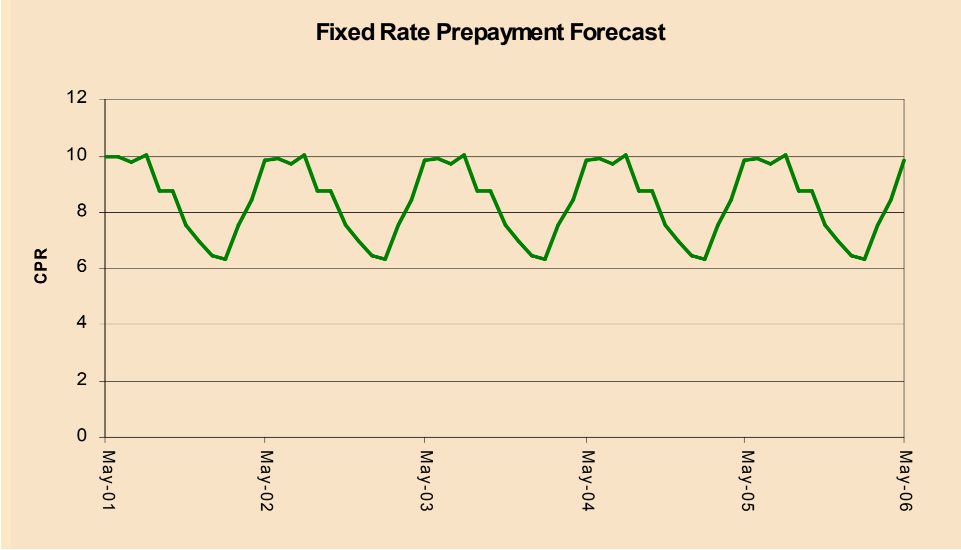
Existing Model Factors

The factors in the fixed-rate MBS prepayment model are seasonality, turnover, aging, the interest-rate (refi) effect, burnout and the points effect. In addition, this release of the model introduces a home price appreciation factor.

Turnover & Seasonality

Turnover is the component of prepayments which occurs in the absence of a refinancing incentive due to natural housing turnover. It tends to be seasonal in nature and depends on the age of the loan. For example, a greater proportion of people tend to move in the summer and most people tend to not sell their home within 12 months of obtaining their mortgage on it. Figure 1 illustrates the seasonality pattern for a seasoned discount FNMA 30 Year pool.

Figure 1
Seasonality on discount FNMA 30 Year Pool



Aging

Aging impacts both premiums and discounts; however, premiums tend to reach their peak prepayment speeds (holding refinancing incentive constant) considerably earlier than discounts. Our model captures this transition in a continuous, bounded fashion. Figure 2 illustrates the aging component of turnover for a moderate premium.

Figure 3 displays an example of aging for a deep discount, a current coupon and a premium pool. The effects of seasonality and burnout (on the premium) have been suppressed.

Figure 2

Aging Component of Turnover for Moderate Premium

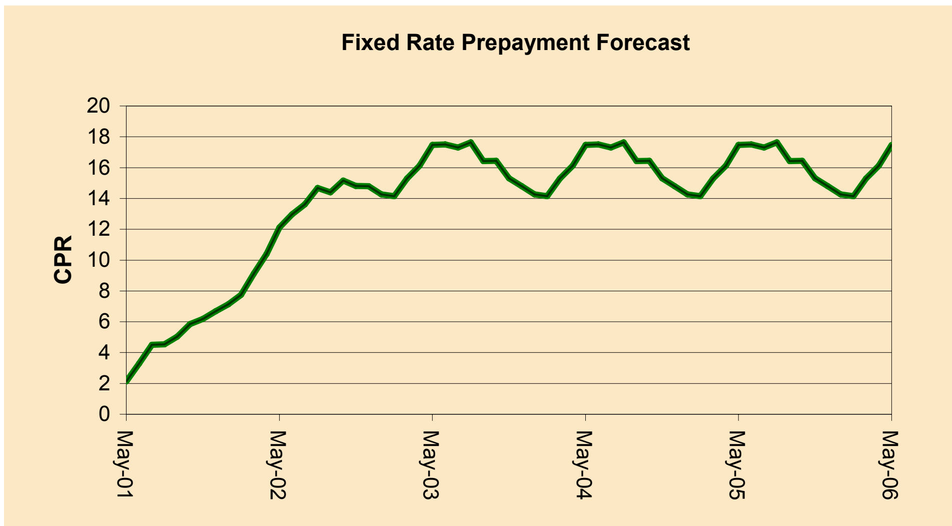
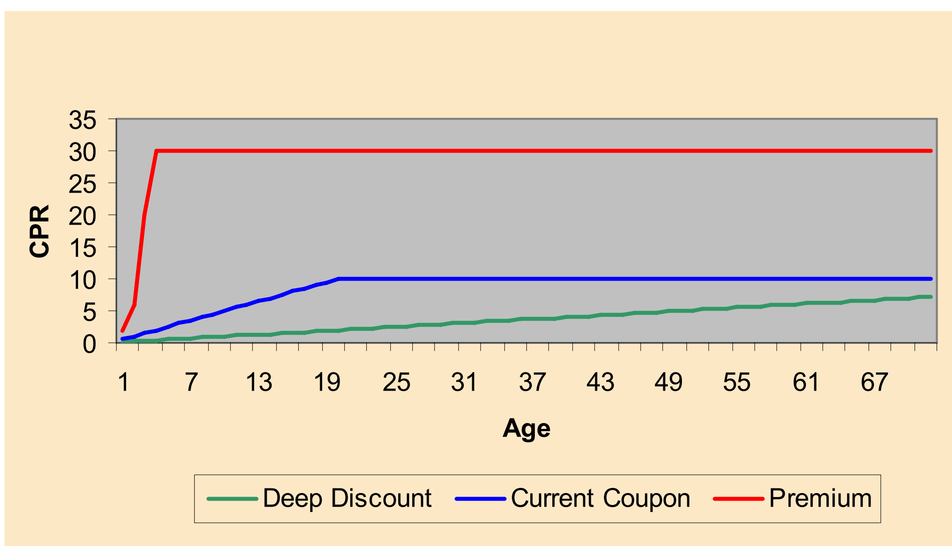


Figure 3

The Aging Effect



Refinancing & Burnout

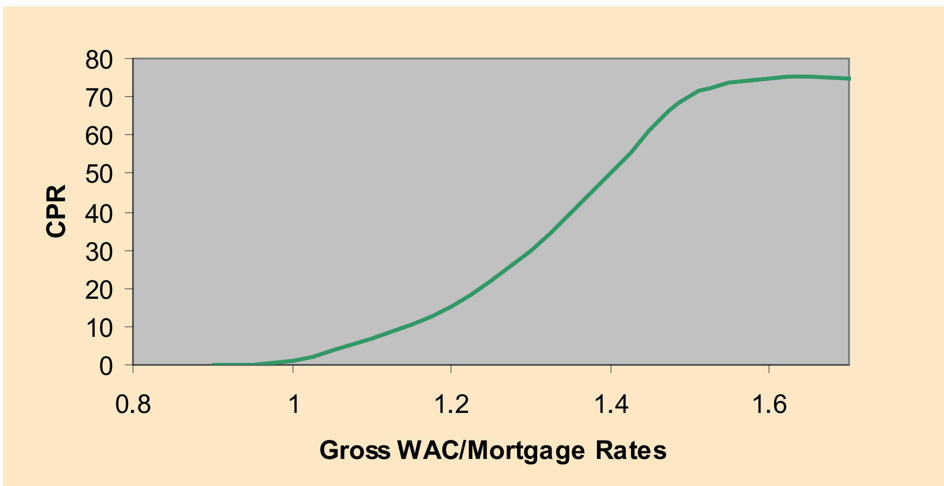
The most significant determinant of residential fixed-rate MBS prepayments is the level of current mortgage rates relative to the weighted-average rate on the pool of mortgages. When rates are sufficiently low relative to the rates held by borrowers, prepayments due to refinancing increase.

We measure this refinancing incentive by taking the ratio of the borrowers' weighted-average coupon (Gross WAC) to a mixture of recent net mortgage rates. For the market reference rate, we weight and sum the last three to four months of mortgage current coupon rates; the exact weights are based on historical data.[1] The reason for using lagged rates is that there is some amount of delay between drops in rates and increased refinancing.

Figure 4 displays a sample refinancing incentive curve. As the ratio between gross WAC and the reference net market rate increases past 1, refinancing begins to pick up and peaks at a fairly high ratio, then levels off.

Figure 4

The Refinancing Incentive Curve



Given a constant refinancing incentive over time, prepayment speeds tend to decrease after an initial spike. If a given pool is exposed to similar (high) refinancing incentives at two different points in time, the second time the pool tends to have lower prepayment speeds due to refinancing. This feature of MBS pools is known as burnout and is due to borrower heterogeneity.

[1] For more about mortgage current coupons and their dynamics relative to Treasury or Libor/Swap rates, see [1].

The S-shaped curve in Figure 4 is a composite based on a variety of borrowers living in different states who face different sets of financial and non-financial costs. In addition, some borrowers pay greater attention to the level of rates than others. As rates drop, the more aggressive refinancers tend to leave the pool first, effectively changing the shape of the curve as they exit.

Our model has an additional component to burnout called reversion, which tends to decrease the level of burnout over extended periods of time. This feature is meant to capture a variety of effects that make borrowers more sensitive to interest rates.

Points

In a given origination month, borrowers obtain mortgages with a variety of interest rates. Those obtaining rates at the low end of 'average' rates generally have paid points. This implies that (a) they had the cash to do so and (b) they are planning to keep their new mortgage long enough that the benefits from the lower rate outweigh the cost of points.

On the other hand, this means that borrowers who obtained rates above 'average' rates did not pay points; hence they either did not have the cash to do so or are planning to move fairly soon and, therefore, did not wish to pay points.

The points effect uses a variable called Relative WAC, which is the difference between the Gross WAC and the average prevailing net rate over the quarter. Large values of this variable, therefore, indicate the presence of borrowers who are either credit-constrained or should have higher than average initial turnover. We model the presence of credit-constrained borrowers by changing the shape of the S-shaped refi-incentive curve for premiums and the higher turnover by changing the aging curve for discounts. Figures 5 and 6 show the impact of points on each of these factors.

In contrast to the previous version of the prepayment model (v4.3.1), the points effect does not directly impact the burnout parameters of the model.

Figure 5

The Effect of Points on Refinancing

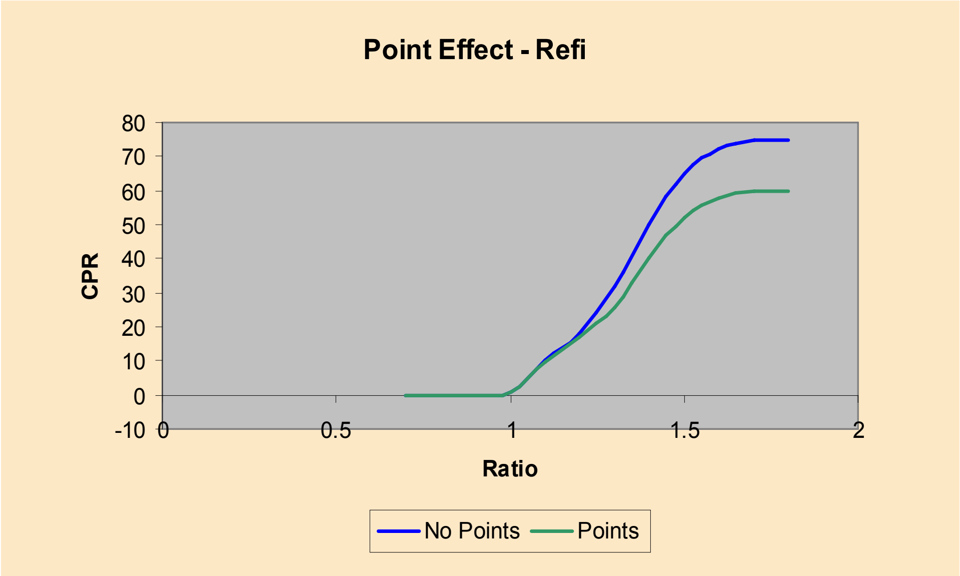
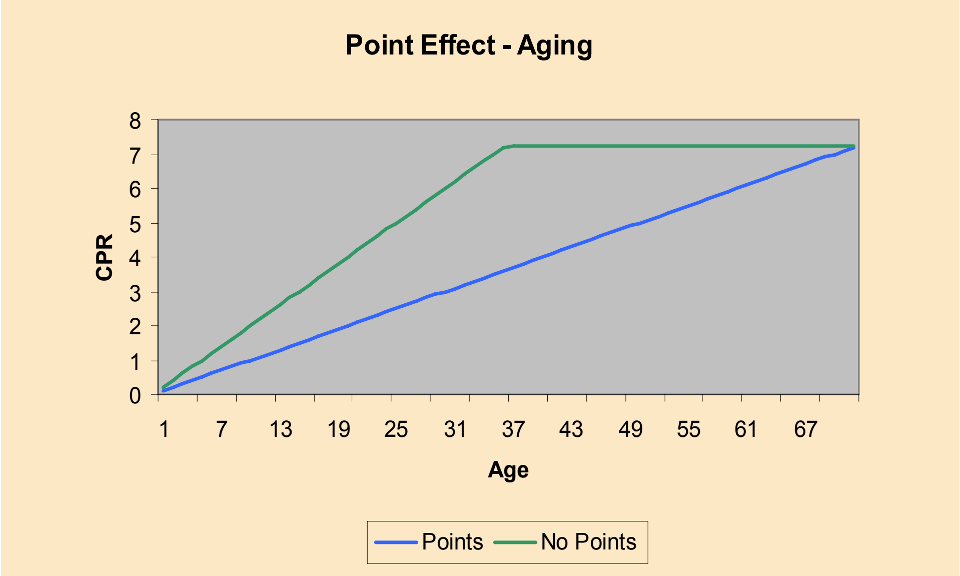


Figure 6

The Effect of Points on Aging



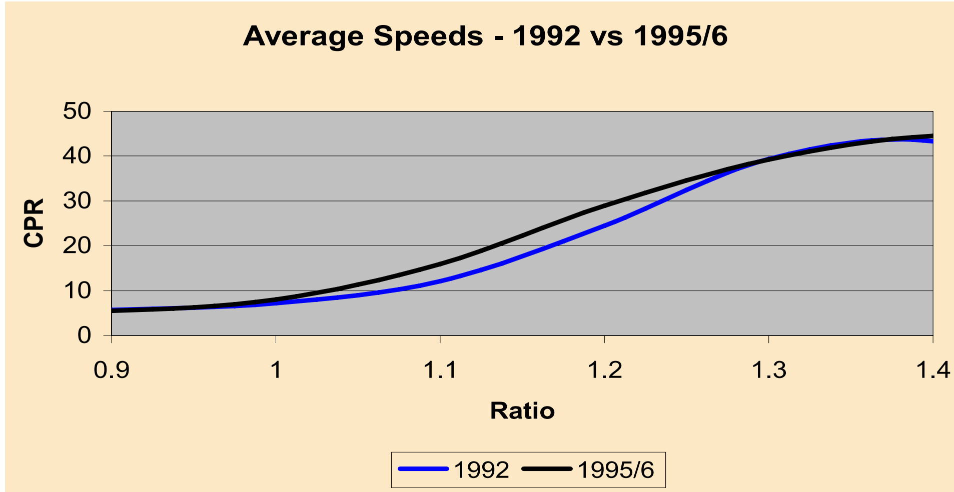
A New Model Factor: The Home Price Effect

Figure 7 displays prepayment data from similarly seasoned cohorts originated in 1992 vs. 1995-6, with CPR plotted against ratio of WAC to current coupon.

It is important to be able to explain differences of this sort in terms of economically meaningful variables. While we could model this phenomenon by having different refinancing curves for different origination years, it would add no insight as to underlying causes and leave us in no position to predict which past curve a given future year will resemble, if any.

Figure 7

Differences in Refi Incentive by Origination Year



In Table 2 we compare the averages and ranges of home price appreciation experienced by the two different origination groups in Figure 7.

Table 2

Annual Home Price Appreciation

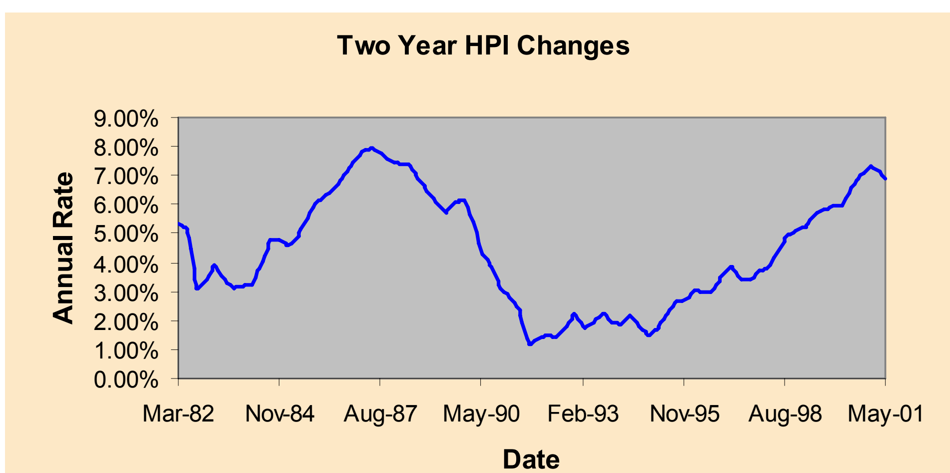
Origination	Mean Appreciation	Min	Max
1992	3.6%	0.8%	8.0%
1995-6	4.7%	0.8%	8.0%

While the range of annual home price appreciation values is similar for the two groups, the average appreciation is significantly higher for the second one. This suggests a possible underlying cause: given a particular refinancing incentive due to rate levels, the presence of significant home price appreciation can lead to an additional incentive to refinance. In a favorable rate environment, this would allow the borrower to access the increased equity in their home at a relatively low, tax-subsidized rate.

Figure 8 shows the annualized two-year home price appreciation rates from March 1992 through May 2001 for 'conforming' homes.[2]

Figure 8

Two Year Changes in the Conforming Home Price Index



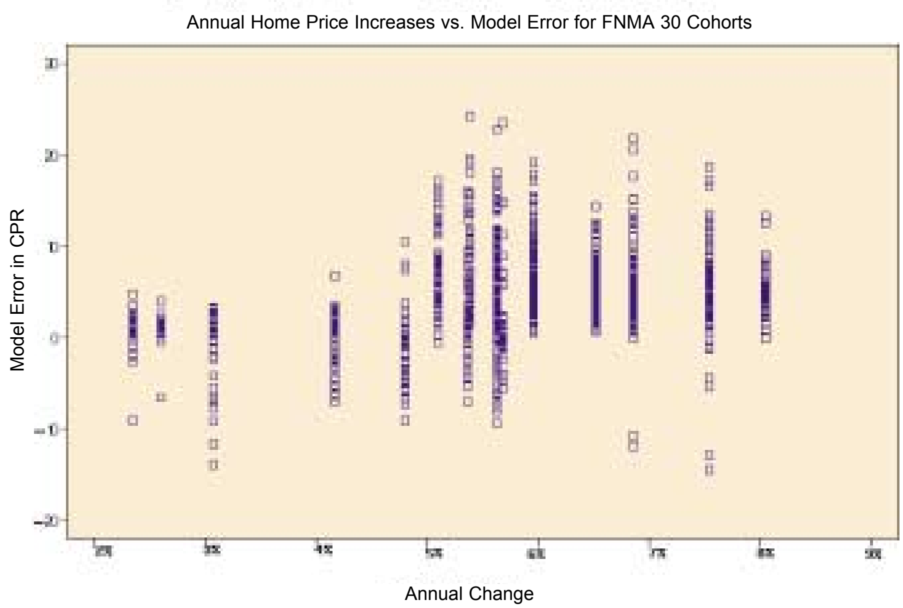
[2]A conforming home is one where a loan with LTV=80 would not exceed the conforming loan limit.

Since the early 1980s, the annualized rate has varied from just above 1% to over 7% per year. For a $200,000 home with an initial loan amount of $180,000, the range of values for home equity at the end of two years in these extreme cases would vary from $24,000 to just under $49,000.

While these scenarios present a compelling reason to consider home price appreciation as an economic factor, more evidence is needed before including an additional model term. In Figure 9 we display the relationship between the error in a prepayment model that uses all the factors we have listed, excluding home price appreciation, and the national average two-year home price appreciation. We have restricted the data in the graph to cohorts seasoned at least 9 months and ratios under 1.25 to leave out borrowers for whom it is 'too soon' to refinance, or for whom a purely rate-based incentive exists to refinance.

Figure 9

Model Error for non-HPI model vs. Annualized 2-year HPI Increase

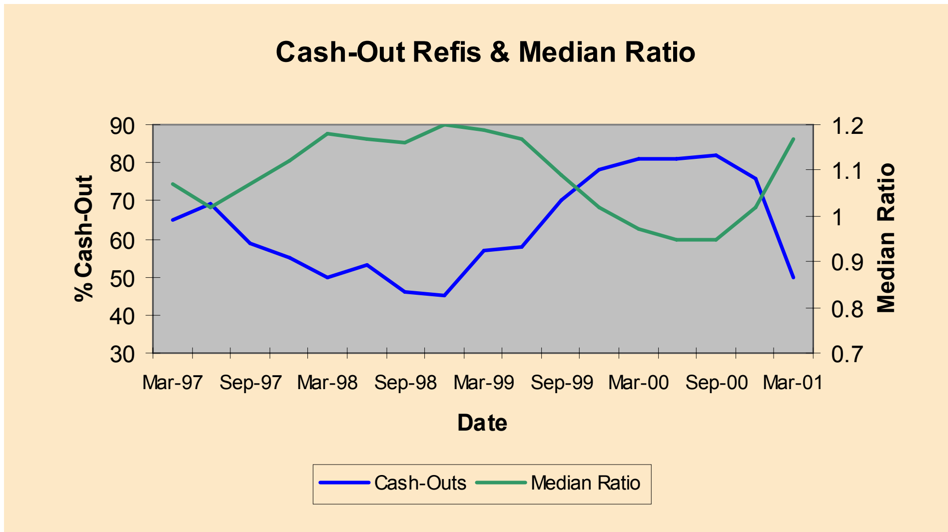


Because the y-axis is actual CPR minus model CPR, we see that beginning around the 5% annualized change value there is an increase in actual CPRs which is not explained by the existing factors. Subsequent analysis showed that this error was related to home price appreciation in a statistically significant way and that relationship was non-linear. In addition, we found that the home price effect interacted with the refinancing incentive ratio as well. While the contribution to prepayment speeds of the effect varied across our conventional, government and whole-loan collateral types, it was found to be significant for all 30 and 15 year collateral types.

In Figure 10 we examine the relationship between rate-based refinancing and cash-out refinancing and how they have varied recently using quarterly refinancing data from Freddie Mac.[3] Cash-out refinancing is captured by looking at the percentage of refinanced loans that resulted in a loan amount at least 5% larger than the previous loan. The amount of rate-based refinancing can be inferred from the median ratio of the old loan to the new loan.

Figure 10

Percent of Cash-Out Refinancings as a Function of Median Ratio



The relationship between cash-out and rate-based refinancing is remarkably close to a mirror image, showing a strong negative association. During the 1998 refinancing waves, roughly half of refinancings were cash-out, while the median ratio was over 1.1. Throughout 2000, however, over 80% of refinancings took cash-out; moreover, the median ratio tells us that more than half of refinancers took a slightly higher interest rate to access the cash. Finally, in the first quarter of 2001, we see a spike in the median ratio accompanied by a drop in cash-out refinancing back to the 50% levels of 1998.

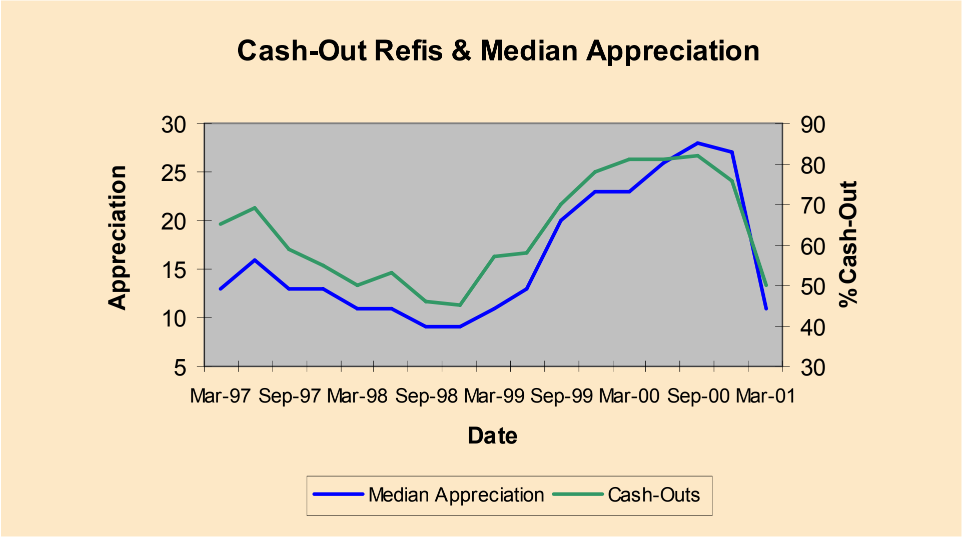
Next, in Figure 11 we take another look at the relationship between home price appreciation and the proportion of cash-out refinancings. On the left axis we have the median amount a refinanced property had appreciated between the start of the original loan and the refinancing. On the right axis, we see the same cash-out refinancing series from Figure 10. While it is almost a tautology that some amount of appreciation must have occurred

[3] The data is based only on Freddie-Freddie refinancing and can be obtained on Bloomberg using ALLX FREQ <go>.

for a cash-out refinancing to occur[4], Figure 11 shows that there is a very strong positive association between the median amount of appreciation and the proportion of refinancing that is cash-out refinancing.

Figure 11

Median Home Price Appreciation and the Proportion of Cash-out Refinancings



Taken together, Figure 10 and 11 supply strong direct evidence that the association between unexplained model error and the HPI shown in Figure 9 may be causal and fundamental. In the next section, we describe how our home price effect factor works.

Form of Home Price Effect

The home price effect has three major components: aging, an interaction with the median ratio, and the magnitude of home price appreciation. Each of these components and their interactions must be taken into account to generate accurate forecasts of the contributions to prepayments of the home price effect.

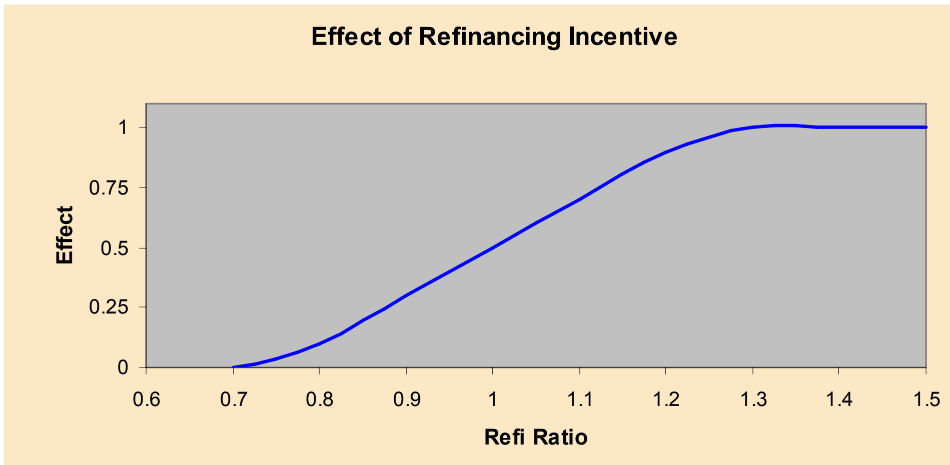
First, aging is needed because borrowers who have just obtained a mortgage are less likely to refinance than those who have held their mortgage for some time. This is as true for refinancings based on home price appreciation as it is for other types of refinancing. Our implementation of the Home Price Effect allows for an aging period for cash-out refinancing that is different from the aging that turnover and rate-based refinancing have.

[4]Another source of additional equity is scheduled principal paydown; a closer look at the data shows that the median age at refinancing is not enough for this to be the more significant source of equity build up.

Next, borrowers are less likely to take equity out when the cost of doing so is a significantly higher new mortgage rate. Hence, the ratio of the current loan to prevailing market rates is an important determinant of cash-out refinancing. Moreover, as that ratio becomes more favorable to the borrower, purely rate-based motives take over, and the marginal effect of home price appreciation past a certain ratio should go to zero. Figure 12 illustrates the impact of WAC to current coupon ratio on the home price effect.

Figure 12

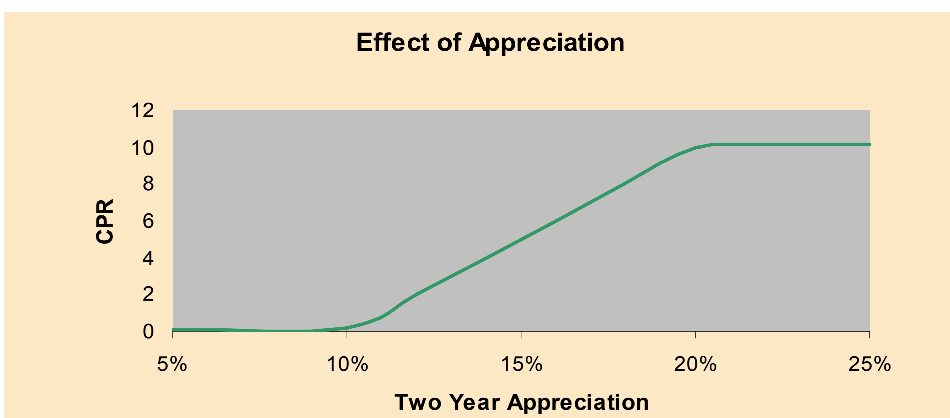
The Effect of Refinancing Incentive on Home Price Effect



Finally, the impact of the amount of home price appreciation on increases in cash-out refinancing needs to be modeled. We measure this increase by looking at the accumulated two-year increase in the national home price index.[5] Separate indices are used for conforming and jumbo loans. Figure 13 provides an example of the relationship between the two-year increase in HPI and increase in prepays due to cash-out refinancing.

Figure 13

The Effect of Two-Year Home Price Appreciation on Prepayments

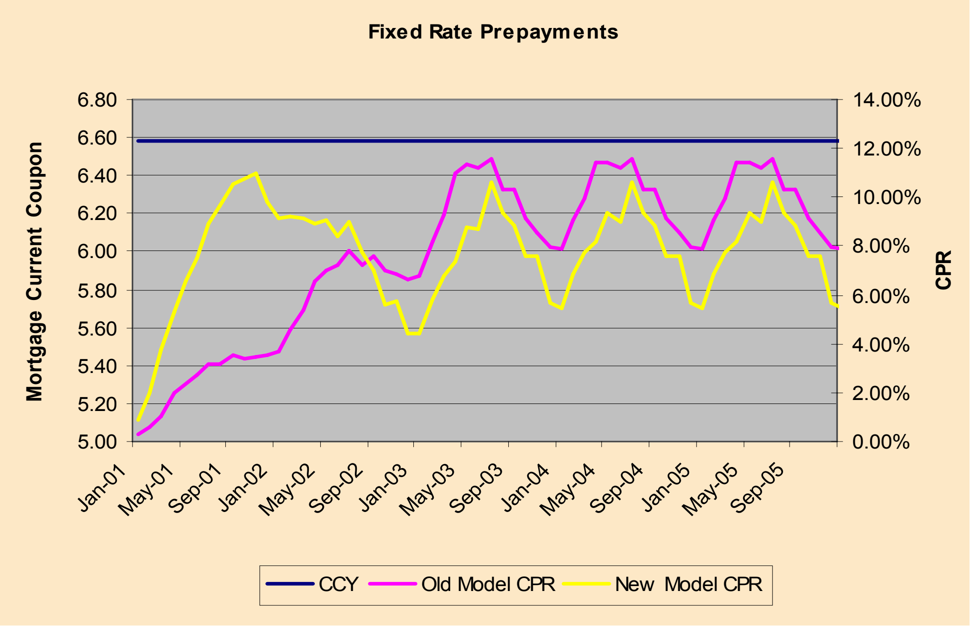


[5] The more geographical variation there is in home price appreciation, the less accurate this model factor will be. Naturally, loan level models together with state or zip code level data would better reflect the effects of this variation.

Figure 14 shows the impact of the home price effect on prepayment forecasts for a cusp coupon. The impact of the Home Price Effect is apparent in the increased speeds in the first part of the forecast, but results in comparable speeds later on.

Figure 14

Impact on Forecast



Software Implementation of Home Price Effect

With the version 4.3 API, it is not possible to forecast the home price index using a vector. However, two new files have been added to the monthly data file shipment to allow some forecasting capability. These files, called *confhpi.txt* and *nonconfhpi.txt*, contain monthly values of the home price index for conforming and non-conforming homes going back to 1977 and 1980, respectively. After the entry for the current month, there is a final line that allows the user to forecast a long-term home price index growth rate. The default value of -99 allows the user to select a forecast which goes from the most recent value to the historical mean growth rate over 24 months. Positive values of this field result in a forecast that varies linearly from the most recent value to this forecast growth rate over 24 months.

Additional Comparison of v4.3.2 and v4.3.1

Appendix 1 contains graphs of a model forecasts vs. history for a variety of recent origination across several collateral types. Out of sample tests for our last release v4.3.1, showed several general trends in recent data that have been incorporated into v4.3.2 in addition to the new home price appreciation factor.

Aging: The aging ramp for premium loans has almost completely disappeared. This means that if a set of loans become premiums even one or two months after origination, a substantial proportion of them will refinance. In addition, the steepness of the transition in aging ramps between premiums and discounts has increased. This implies that a cohort now seasons as a premium at a lower ratio than before.

Points Effect: The strength of the points effect has increased. This is reflected in a larger difference between high and low relative WAC pools: high relative WAC pools which are discounts season faster; premiums prepay more slowly initially, but cure over approximately two years. The direct impact of points on burnout has been dropped.

Lag Structure: Starting with v4.1 of the model, we have observed a shortening in the lag structure of prepayments and this trend has continued into v4.3.2. Shorter lags between rate moves and prepayment speed changes reflect increased efficiencies in the refinancing process; such as better access to rate change information and a stream-lined refinancing process.

Valuation Results & Out of Sample Testing

Table 3 compares OAS, WAL, equivalent PSAs, effective duration, and effective convexity for a selection of conventional and government 30-year pass throughs. The WAC/WAM assumptions coincide with Bloomberg assumptions as of 5/29/2001, including the LIBOR/swap curve.

The first set of OAS, Current Curve PSAs and Effective Durations assume home price appreciation continues at rates close to those seen recently, at 7% per year. The second set uses the current value of home price appreciation with a reversion over 2 years to the average historical rate, which is approximately 3.5% per year. The final set are from v4.3.1 of the model, which does not have a home price effect.

Comparing the first and second sets of numbers, it is clear that there is a large increase in prepayment speeds if we use the higher HPI growth assumption. This is particularly clear when we look at the 6s and 7s, which rise from the 160-360 PSA range to the 265-548 PSA range, because these coupons have little or no rate-based refinancing incentive.

Table 3

Valuation Results

Bond	Model Version	Home Price	OAS	WAC PSA	Effective Duration	Effective Convexity
FG6	4.3.2	MAXIMUM	49	357	4.97	-1.34
FG7	4.3.2	MAXIMUM	47	548	2.79	-2.25
FG8	4.3.2	MAXIMUM	52	650	1.70	-1.32
GN6	4.3.2	MAXIMUM	15	265	5.01	-1.30
GN7	4.3.2	MAXIMUM	26	455	2.91	-2.61
GN8	4.3.2	MAXIMUM	30	679	1.30	-1.35
FG6	4.3.2	AVERAGE	43	223	4.92	-1.32
FG7	4.3.2	AVERAGE	47	363	2.95	-2.06
FG8	4.3.2	AVERAGE	68	469	2.04	-1.22
GN6	4.3.2	AVERAGE	18	163	5.01	-1.67
GN7	4.3.2	AVERAGE	27	380	2.91	-2.31
GN8	4.3.2	AVERAGE	38	593	1.52	-1.31
FG6	4.3.1	N/A	40	235	5.23	-1.79
FG7	4.3.1	N/A	48	371	3.02	-2.29
FG8	4.3.1	N/A	68	488	2.08	-1.26
GN6	4.3.1	N/A	15	131	5.00	-1.11
GN7	4.3.1	N/A	27	374	3.00	-2.37
GN8	4.3.1	N/A	43	583	1.63	-1.34

Next, we see that the second and third sets of speeds are fairly close; this reflects the fact that under 'normal' home price appreciation scenarios, changes to model parameters are relatively minor.

The results on valuation metrics are comparable: the second and thirds sets of numbers are closer to each other than the first is to either. We see an increase in OAS on discounts and a decrease for premiums due to the higher speeds caused by high home price appreciations; this is accompanied by slightly lower durations than in v4.3.1.

Appendix B shows some out of sample performance charts for the new model. The charts show different origination year and coupons across the x-axis with average CPR during the Jan-May 2001 period on the y-axis. We see that with the exception of 1998Q3 origination, FNMA 30 prepayments for 6.5s and 8.5 are predicted fairly well by the model. For GNMA 30s, 2000 origination stands out and for FNMA 15s, 1992 and 1999 originations seem to deviate from model predictions.[6]

[6] In general, with the exception of some 2000 originated 7.5s, the model seems to follow actuals across different origination year/quarters quite well. Please see our performance reports at www.ad-co.com or contact us for more detailed data.

Conclusion

Release 4.3.2 of the Andrew Davidson & Co. MBS fixed-rate prepayment model incorporates a new economic driver of prepayments in the form of the Home Price Effect. This second factor helps explain much of the fluctuation in cusp coupon performance and differences between different origination years. Beyond the statistical relationships discovered within the prepayment model data set, data on cash-out refinancing and median refinancing ratios from Freddie Mac support the view that increase in home equity is an additional motive to refinance for a significant proportion of borrowers.

Given that there has been considerable variation about the overall mean for home price appreciation rates, as well as long periods of high autocorrelation, using a reversion to this average over 24 months is a temporary solution to the problem of accurately forecasting this input. We will address the problem of more accurately forecasting this variable based on other relevant economic variables and the autocorrelation structure of the series in subsequent research.

Modeling & Testing Team

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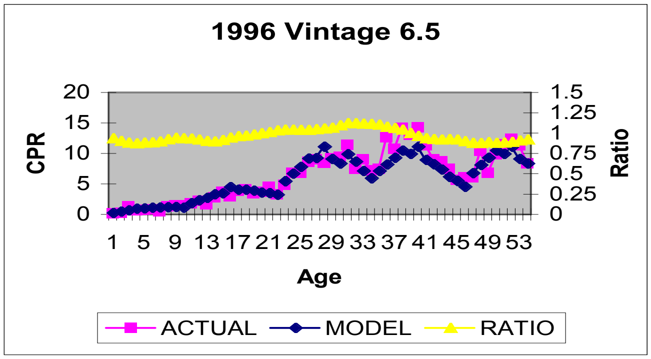
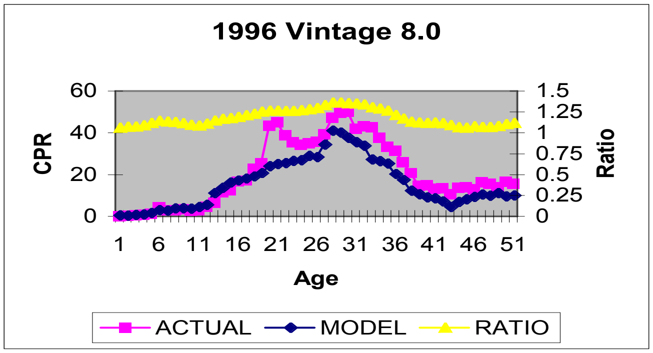
[2] Mortgage Risk Assessment Corporation. Home Price Indices: Methodology. Available for download at the following web address: https://www.homepriceanalyzer.com/Hpimeth.doc.

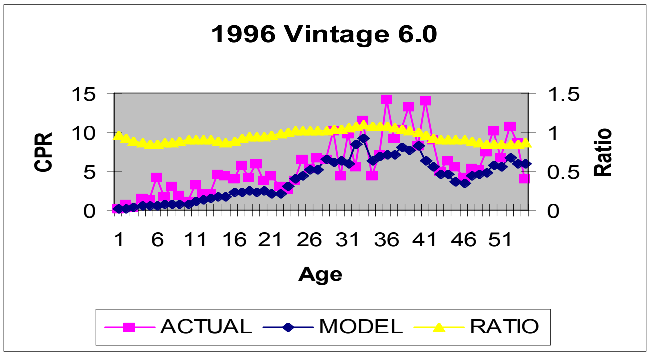
[3] Dreiman, Shelly. *Using the Price to Income Ratio to Determine the Presence of Housing Price Bubbles*. OFHEO, 2001.

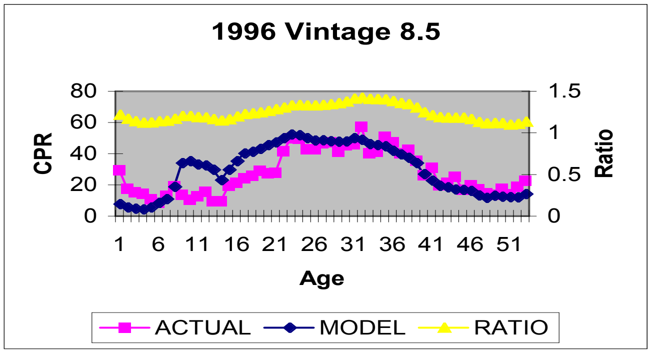
GNMA 30s



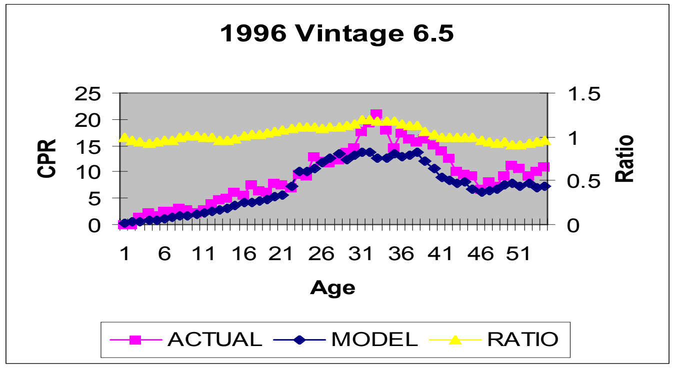


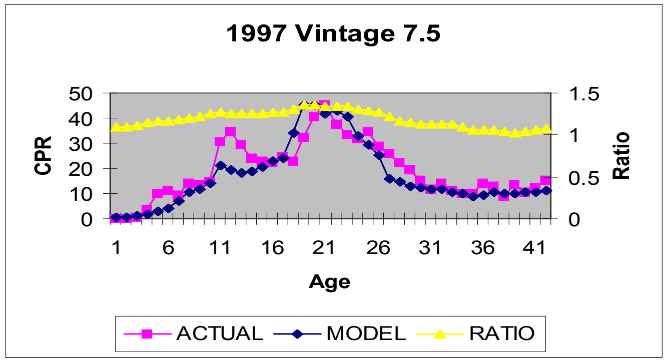
FNMA 30s



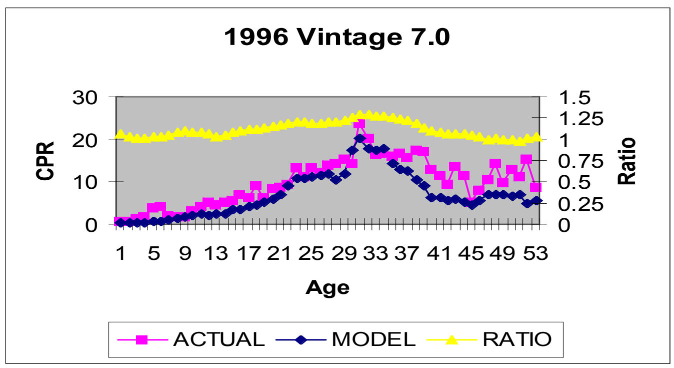


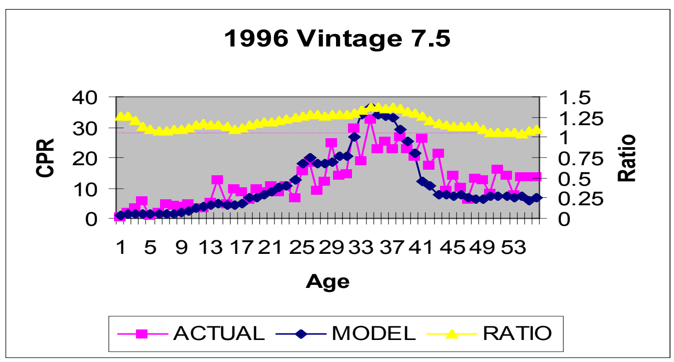
Conventional 15s





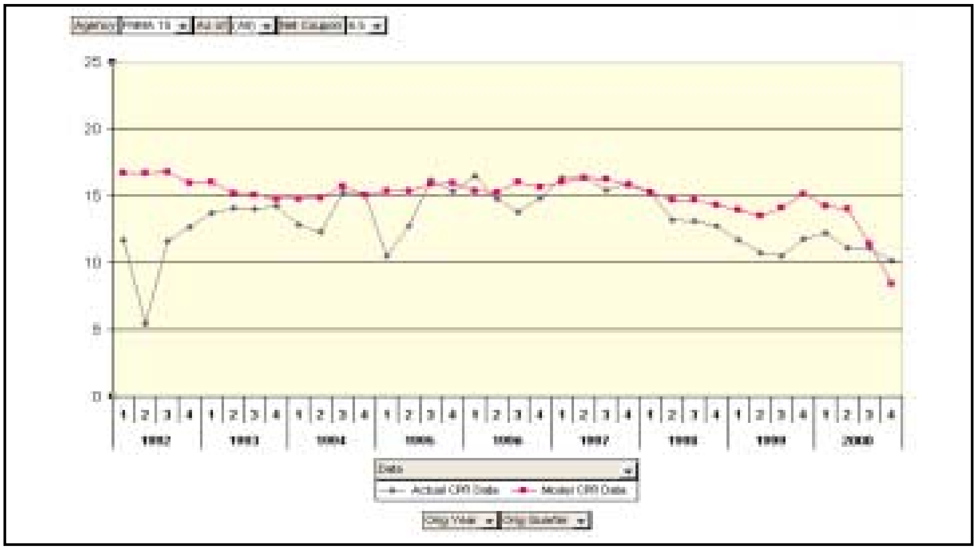
GNMA 15s



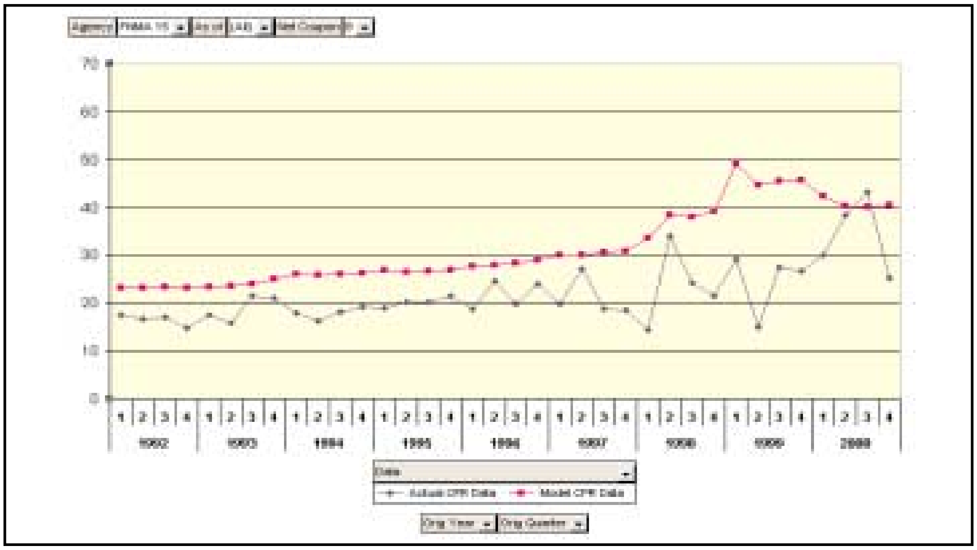


APPENDIX B: Out of Sample Results by Origination Year & Quarter for Selected Coupon & Collateral Types (Average CPR over January-May 2001)

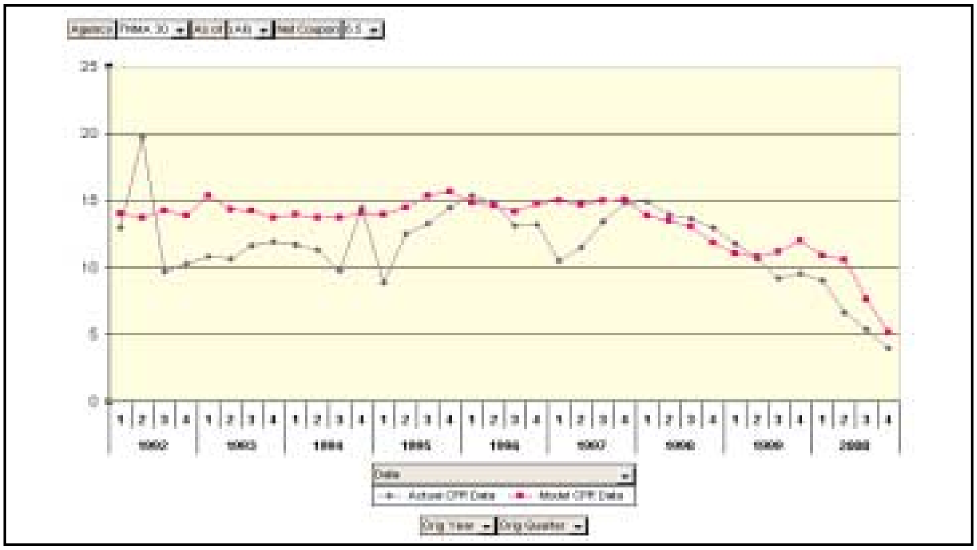
FNMA 15
Net Coupon 6.5



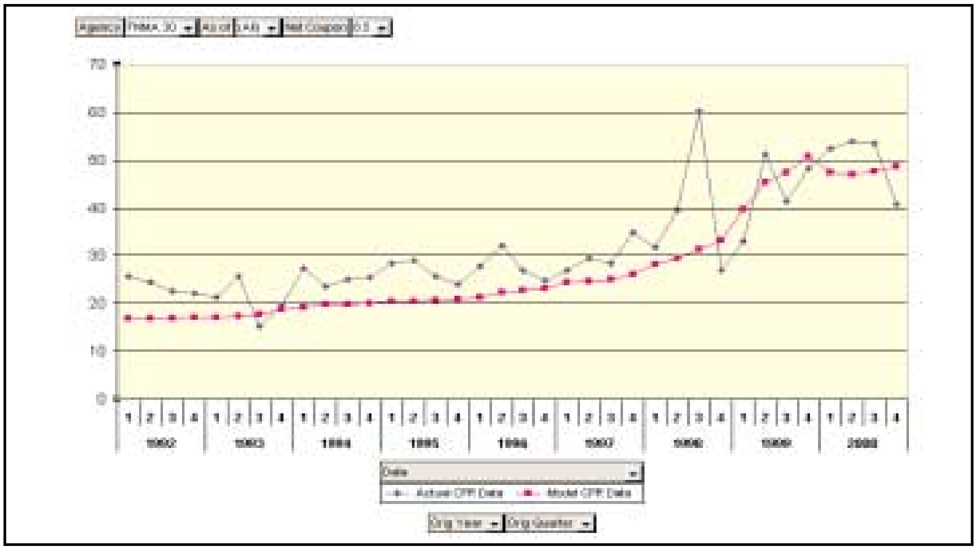
FNMA 15
Net Coupon 8.0



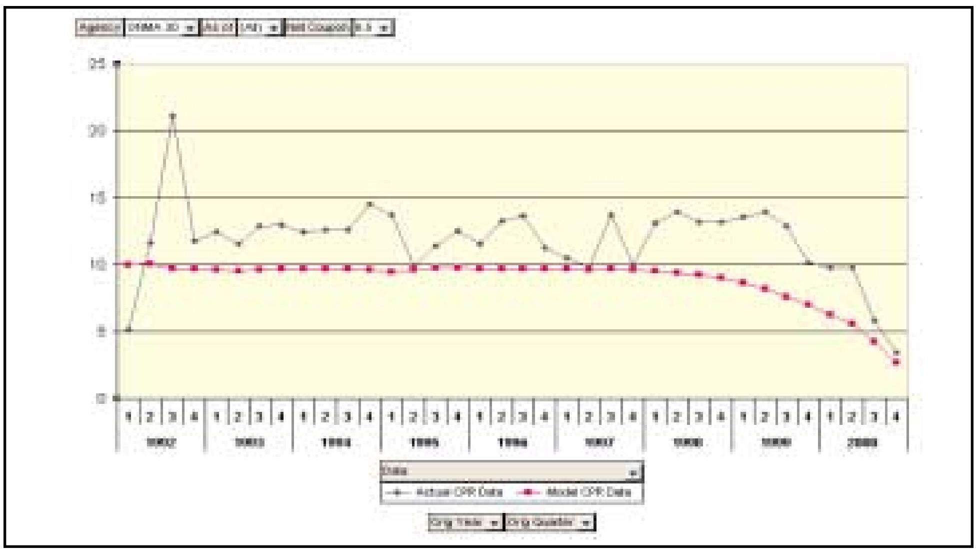
FNMA 30
Net Coupon 6.5



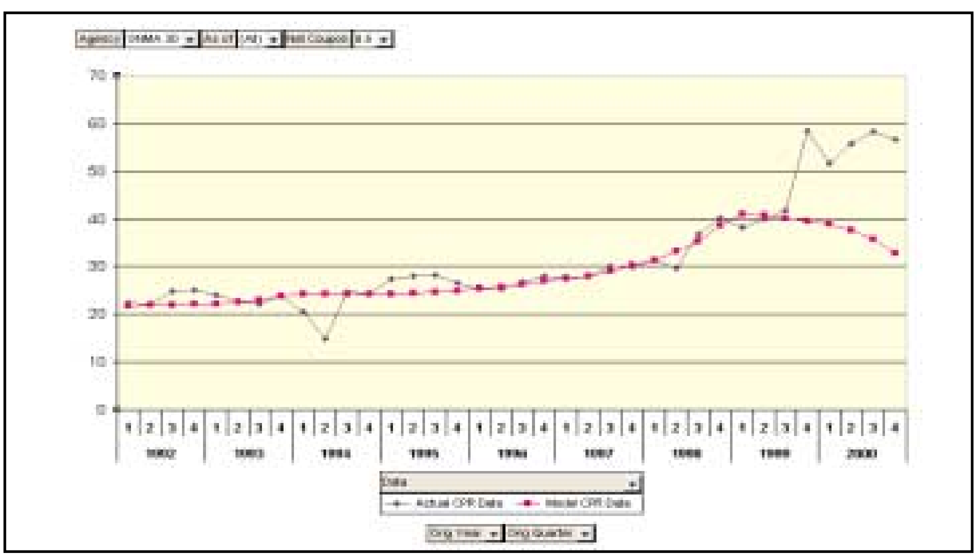
FNMA 30
Net Coupon 8.5



GNMA 30
Net Coupon 6.5



GNMA 30
Net Coupon 8.5



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