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The Relationship Between Exchange Rates, Swap Spreads, and Mortgage Spreads

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I. INTRODUCTION

It is widely known that the mortgage pass-through spread is well correlated with the swap spread. A mortgage pass-through can be judged rich or cheap by its relative level to the swap spread. This relationship broke down in the second half of 1997. We suggest that, as a reference level for mortgage spreads, the swap spread is tainted by the recent Asian turmoil. Before this Asian economical crisis blows over, we propose a stand-in for the swap spread.

We analyze the interplay between US dollar LIBOR swap spreads, currency exchange rates, and the option-adjusted spread (OAS) of mortgage-backed securities. We observe that

(i) There is a remarkable correlation between the three;

(ii) A major component, which we refer to as the core, of the swap spread reflects the health of the US economy; this is defined in terms of interest rates and exchange rates;

(iii) The recent divergence of the swap spread from this core is a result of the current Asian currency turmoil;

(iv) Hence, borrowers who have no exposure to Asia should pay a spread commensurate with the core swap spread rather than the swap spread; these include US mortgage borrowers and, by extension, the mortgage-backed securities to the degree that investors have access to non-LIBOR funding.

We will discuss some investment implications.

Several authors have studied the swap spread and its relation to various benchmark parameters. So far, there does not seem to be a compelling explanation as to what drives the swap spread. Robert Kulason listed eight theories and made the point that none seems to be supported by hard evidence.[1] Earlier, a previous article reported negative results in the testing of some of these hypotheses.[2]

Consider the five-year swap rate. It is approximately equal to the expected average of the three-month LIBOR rates L_3 for the next twenty quarters. Likewise, the five-year Treasury (on-the-run) rate is approximately equal to the expected average of the three-month special repo rates R_3 for this particular Treasury security during the twenty quarterly periods in its lifetime. Therefore,

Swap Spread=Expected Average of (L_3-R_3)

The interest rate risk premiums in both the swap rate and the Treasury have been ignored since they are roughly equal and cancel out. If we let GC_3 denote the three-month repo rate with general Treasury collaterals, then the above equation can be re-written

Swap Spread=Expected Average of (L_3-GC_3)

+ Expected Average of (GC_3-R_3)

= Expected Average of TED Spread

+ Expected Average Financing Advantage in owning the Treasury

We have identified GC_3-R_3 as the financing advantage since it is non-negative and becomes positive when the Treasury note is special.[3]

As for L_3-GC_3, the TED spread, it is mainly the credit risk premium for lending to the Euro borrower as opposed to the US Treasury. The above displayed equation shows how the credit risk premium in the TED spread gets transmitted to the swap spread.

Following is one arrangement where the credit risk can actually come into play.

The direct counterparty risk in a swap is negligible, since no principal is involved. However, in order to realize the swap spread, an investor can deposit the notional amount into some Euro bank as the source of the float, thereby becoming exposed to the credit risk from that institution. Even though an investor can, on deteriorating credit of that bank, switch to a different one at month end, one would be exposed to the credit risk of this second institution. In short, for the term of the swap, one is always exposed to the risk of an unforeseen failure -hence, the risk premium in the swap spread. Now if a second investor generates his own float and enters into a swap, he earns the swap spread because he is paying the same LIBOR as the first investor; in other words, he is paying generously as though he is exposed to credit risk.

This risk premium summarizes the risk of lending to the entire food chain of Euro borrowers. The banks are only the most visible link. The ultimate borrower could be an oil importer, a real estate developer, a hedge fund that finances mortgage securities at LIBOR, or some business or government agency in a developing country.

Furthermore, this credit risk can be decomposed into a background risk that varies over time with the general health of the US Eurodollar economy, and the

[1] See *Bond Market Roundup: Strategy*, Salomon Smith Barney, October 24, 1997.
[2] See *Bond Market Roundup: Strategy*, Salomon Smith Barney, September 20, 1996 and November 1, 1996.
[3] It is on the suggestion of Janet Showers that we use GC_3 in place of the three-month Treasury rate in an earlier version.

risk due to transient and discrete events from different causes at different times. In other words,

Swap Spread = Event Risk Premium

+ General US Risk Premium

+ Expected Average Financing Advantage in Treasury

The last two terms can be combined and called, for lack of a better name, the *core swap spread* or the background swap spread.

In this paper, we propose two variables that intuitively should correlate well with the general health of the Euro dollar economy, and which we found to actually correlate well with the swap spread. They are (1) the level of US interest rates, and (2) the strength of the US dollar, the latter to be measured in terms of the dollar exchange rates for the currencies of its major trading partners.

We will first study the five-year swap spread S over the period September 1984 to November 1997. The benchmark interest rate is the five-year US Treasury rate, the first explaining variable. In the next section, we introduce an exchange rate momentum as the second explaining variable. Together, they will define a quantitative surrogate for the core swap spread.

Define a composite exchange rate C as a weighted average of the exchange rates (foreign currency per dollar) for each of the G7 countries except the United States, weighted by the respective approximate GDPs in (trillion) US dollars. Specifically, C is defined to be

$$C = 0.6CA + 1.1IT + 1.1BR + 1.5FR + 2.4GE + 5.1JA$$

where CA is the number of Canadian dollars purchased by one US dollar on a certain day, IT is the number of Italian liras purchased by one US dollar on that day, and so on. Each exchange rate is normalized to its level on September 4, 1984. For example, CA=1 on September 4, 1984, and CA=1.10 on November 24, 1997. (The precision of the weights do not alter our results significantly. Instead of GDPs we could use GDP ranks; the weights for JA and GE would then be 6 and 5, respectively.)

To remove daily fluctuations, we use one-month moving averages for each exchange rate. (This means exponentially decaying weights into the past, so that the weighted time into the past is one month.) A moving average is used because the proposed relation between the currency market and the swap market is fundamental rather than arbitrage-driven (at least not yet), so the day-to-day fluctuation in one is uncorrelated with that in the other. By the same token, a six-month moving average is used for the Treasury Rate Y (the decay rates for the moving averages are chosen to optimize the regressions discussed below).

We compare C to its three-year (exponential) moving average, that is, we define the *dollar momentum* variable

$$X = C - \text{(three-year moving average of C)}$$

A high level of X indicates a dollar strong compared to historical level and, by implication, a healthy US economy.

Since the swap spread is unlikely ever to be negative, we will state it in the logarithmic scale.[4] We use linear regression to find coefficients a, b, and c to best fit the series

$$aX + bY + c$$

to the series log(S). Using data from September 4, 1984 to November 24, 1997, the coefficients are found:

$$\log(S) = -0.325X + 0.254Y - 2.98 + \text{residue}$$

or

$$S = \exp(-0.325X + 0.254Y - 2.98 + \text{residue})$$

The core five-year swap spread is accordingly defined as

$$S_0 = \exp(-0.325X + 0.254Y - 2.98)$$

The linear regression has an R-square of 82%, which means that 82% of the variance in the log(S) series is explained by the fitted series. Note that as the dollar strengthens, X is higher and the core spread is lower. Likewise, if the moving-averaged interest rate Y is high, the business environment is harsh, the Euro lender is more worried and charges a higher risk premium.

On November 24, 1997, we have X=0.384 and Y=6.174. (Y is the six month moving average of the five-year Treasury rate.) The core swap spread is

$$S_0 = \exp(-0.325*0.384 + 0.254*6.174 - 2.98)$$

[4] The momentum variable X can be negative.

= 0.22 = 22bp

The actual five-year swap spread on that day is S=41bp. For an explanation of the 19bp difference, one has to look outside the United States.

Figure 1 tabulates the root-mean-square error of the fit for different choices of the explaining variables. It shows the results for similar regressions of the TED. (In the regression for TED we used the Treasury rate without the moving averaging.)

Figure 1. Regressions of Swap and TED Spreads

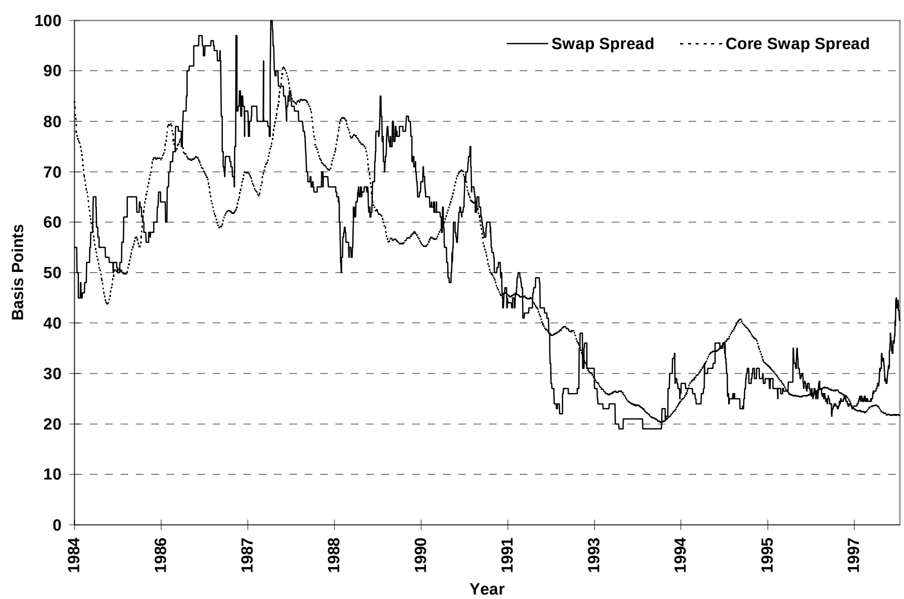
Spread	Explaining Variable(s)	RMS Error (bp)
5Y-Swap September 1984 - October 1997	none; use long term mean	23.0
	Y	16.7
	X	21.3
	X and Y	10.4
TED January 1978 - October 1997	none; use long term mean	75.1
	Y	57.6
	X	78.4
	X and Y	51.8

Source: Smith Barney Inc./Salomon Brothers Inc.

The dollar momentum X by itself has no predictive power over the long-term mean. In the case of the TED spread, the RMSE is actually higher than when using the long-term mean. (That is because the regression is done in the logarithmic scale, where high levels of TED in the data series are compressed and de-emphasized. Adjusting for this convexity bias would improve the RMSE.) The interest-rate variable Y performs much better. Nevertheless, inclusion of X reduces the RMSE significantly.

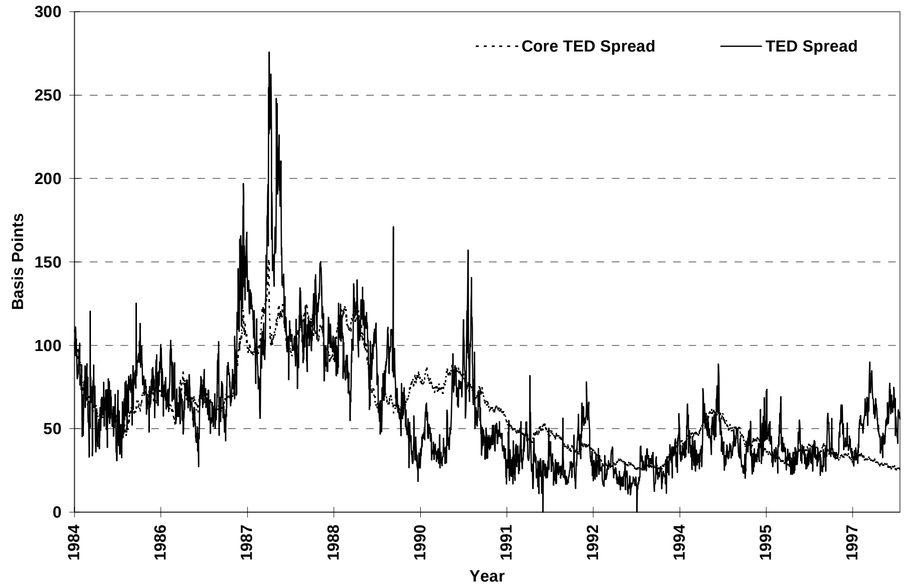
The swap spread and the core swap spread are graphed in Figure 2, and the TED spread and the core TED spread are graphed in Figure 3.

Figure 2. Predicting Swap Spread by Interest Rate and Dollar Momentum



Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 3. Predicting TED Spread by Interest Rate and Dollar Momentum



Source: Smith Barney Inc./Salomon Brothers Inc.

There is a marked divergence of the full swap spread from the core after the first quarter of 1997. We therefore look for some discrete event outside the United States for credit risks. An obvious candidate is the Asian currency turmoil. As a matter of fact, if in addition to the interest-rate variable Y and the exchange-rate variable X, we introduce an Asian exchange-rate variable into the regression, the correlation is significantly improved with R-square at 85% (see Figure 4).

The Asian composite exchange-rate variable C' is an average of the exchange rates (per dollar normalized) of the South Korean won, the Thai baht, the Indonesian rupiah, and the Malaysian ringgit:

$$C' = 100KO + 70TH + 55IN + 22MA$$

The weights used are the respective claims in (billion) US dollars from international banks that report their lendings to the Bank of International Settlements (BIS).[5] In parallel to X, we define

$$X' = C' - (\text{three-year moving average of } C')$$

Only the data after 1993 is used in the regression that produced the Asian curve in Figure 4. There is some justification to this. The claims on the Asian countries from the banks in the BIS reporting area increased from under $150 billion in 1990 to $367 billion in 1996, surpassing the Latin American level for the first time in 1994. The latter is relatively steady at below $250 billion, with the Eastern European figure also relatively steady at around $100 billion.[6]

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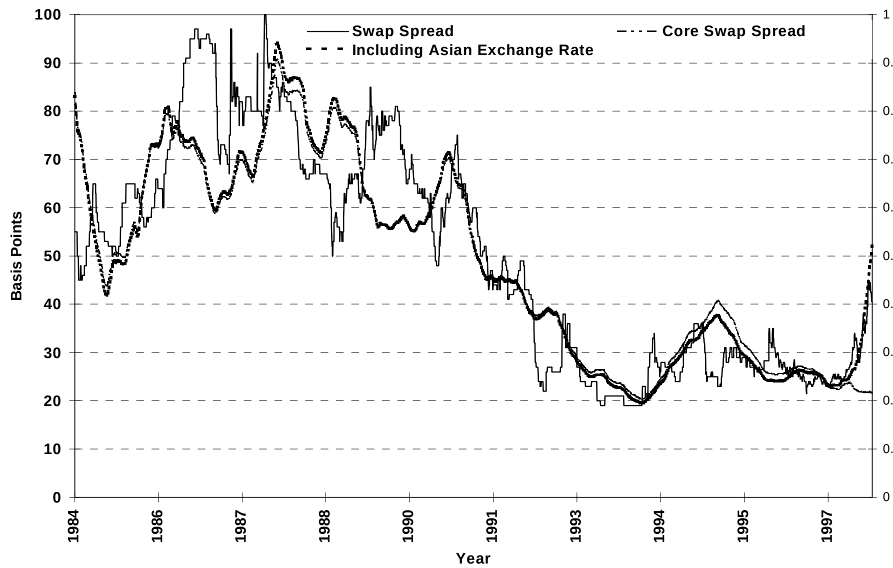
[5] The figures are from "The maturity, Sectorial and Nationality Distribution of International Bank Lending, 2nd Half, 1996," BIS Monetary and Economic Department.

[6] The figures are from "The maturity, Sectorial and Nationality Distribution of International Bank Lending, 2nd Half, 1996," BIS Monetary and Economic Department.

Figure 4. Predicting Swap Spread by Interest Rate and Exchange Rates



Source: Smith Barney Inc./Salomon Brothers Inc.

Our purpose here is to understand the recent divergence of the swap spread from the core swap spread, and the Asian currencies provided the missing piece. They will play no further role in the model.

Under the hypothesis that the Asian financial crisis did cause the recent widening of the swap spread, a logical conclusion is that spreads for borrowers well insulated from that crisis and who are able to obtain non-LIBOR financing should not widen in sympathy, but should move more in line with the core spread, which, as seen in Figure 2, actually tightened during this recent period.

That indeed is observed. Spreads on agency securities, such as Fannie Mae and Freddie Mac, in general tightened, as did the option-adjusted spreads (OAS) of mortgage-backed securities.

The remainder of this paper examines the relation between the mortgage OAS and the swap spread. But first, we offer some comments on the regression model.

We are aware that in fitting to the absolute levels of swap spreads, we may be in danger of picking up spurious correlations. In other words, since we are attempting to predict the slow-changing component of the swap spread, rather than the daily changes, the data series effectively provides only a small sample. Nevertheless, our method is justified in the current context. First, the two explaining variables have intuitive meaning related to the swap spread. Second, the R-square of 82% is high. We show in the Appendix that the probability of a false detection of such a high level of R-square is less than 0.2% in the context of three time series having the characteristics as those in question. We also show that if the R-square were found to be at a lower level, say 40%, then we would be doubtful as to any real correlation; the probability of false detection at that level is about one in four.

We need to emphasize that the dollar momentum variable is useful only in conjunction with the rate variable. A reader looking at the swap spread series and the dollar momentum series would be rightfully skeptical about our claim that there is a relationship between the two; the relationship exists only in the presence of a third series.

Another caution: the mere fact that a bank is located in the United States does not mean that it should be borrowing at the core swap spread. We view the core spread as the fair spread paid by a US borrower who is free of non-US risks whatsoever. A money center bank with a large third-world loan portfolio is not in that category; neither is a multinational corporation that derives a significant portion of its profits from foreign sales.

As observed previously, we view the swap spread as made up of the core spread and risk premiums as a result of discrete events such as the recent Asian turmoil. We do not systematically model these discrete events. The Asian currencies appear above only as an illustration. Past and future divergence between the swap spread and the core may have nothing to do with Asia.

Prediction of the OAS with tradable benchmarks is equivalent to prediction of the price movement conditioned on the movement of the benchmarks, because OAS can be translated, via the models, to price, and vice versa. For the purpose of predicting mortgage OAS, we propose the use of the five-year swap spread and the ten-year Treasury rate. The five-year swap is chosen because it has approximately the duration of a current-coupon mortgage pass-through.

There may well be other variables that correlate better with mortgage OAS. Plausible candidates are the agency spreads and the Fed funds rate, to name just two. However, there is no liquid market for these and we can not hedge an MBS with them, or make from them a synthesized MBS for our portfolio, as we can with Treasuries, swaps, and volatility instruments like caps and floors.

There are several reasons why investors demand a positive OAS from an MBS: (a) liquidity premium; (b) risk of prepayment being higher or lower than the model projections; (c) investors' financing rates, which affect the demand of MBS; and (d) default risk.

Given the size of the MBS market, the first item, liquidity premium, should be near zero or constant for agency current-coupon pass-throughs. The fourth item, the default risk, for agency pass-throughs can also be neglected (or at least taken to be constant over time), thanks to the explicit agency guarantee and the perceived implicit guarantee by the US government. We will examine the OAS for FNMA current coupons.

First, consider the investors' financing rates in the context of what effect a widening swap spread would have on mortgage OAS. In the next section we will look at the issue of unmodeled prepayment risks.

The major mortgage investors are banks, thrifts, pension funds, life insurance companies, agencies (such as Fannie Mae and Freddie Mac), hedge funds, dealers, and foreign investors. Each group has a different mix of funding sources and will demand a commensurate spread for their investment.

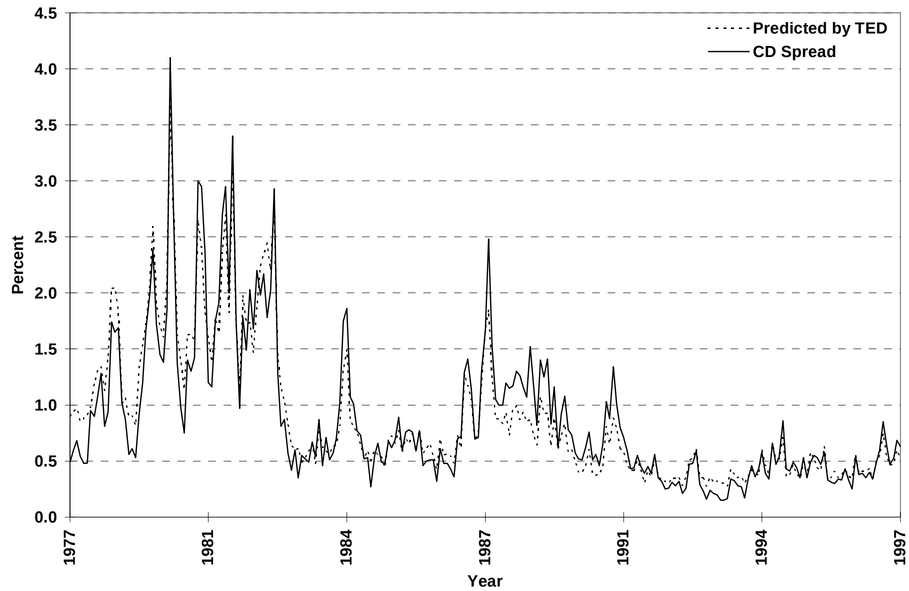
The hedge funds' financing rates are near LIBOR. They would not be able to, and in any case should not, buy an MBS or CMO with OAS significantly below the swap curve. (One exception is a bet against the prepayment model that produces the OAS.) As the swap spread widens, they would demand a higher OAS or reduce their mortgage participation. Other things being equal, this would widen mortgage OAS. A similar observation can be made about dealers.

Agencies like Fannie Mae and Freddie Mac, on the other hand, can finance their mortgage portfolio by debt issuance. Their funding rate over Treasury should therefore be more closely related to the core swap spread as discussed in the previous section than to the actual swap spread. As they become more dominant in the market,[7] a widening of the swap spread from the core spread would lead to an increase of the swap spread relative to mortgage OAS.

Banks derive their funds partly from deposits and partly from interbank borrowing. The latter can be at LIBOR or at the Fed funds rate. The Fed funds rate is itself highly correlated to LIBOR. The correlation between the spread of Fed funds over three-month Treasury and the TED spread is 64% (using data since January, 1974). The correlation of CD spread over Treasury with the TED spread is even higher at 95% (using data since October, 1977. See Figure 5). Like hedge funds, the banks will find it hard to purchase MBS with OAS below swap spread.

[7] Their combined mortgage portfolios now exceed 15% of all mortgages outstanding. See Fannie Mae June 30, 1997 Balance Sheet and Freddie Mac's June 30, 1997 Balance Sheet.

Figure 5. Predicting Spread of Three-Month CD Rate Over Treasury With TED



Source: Smith Barney Inc./Salomon Brothers Inc.

Pension funds and life insurance companies do not need to finance their fixed-income portfolios. Their participation in the mortgage market is not affected by the swap spread, as is the case for the thrifts, whose participation in the mortgage market is mandated by their charter.

Foreign investors who purchase mortgage-backed securities, especially GNMAs, do so for safety of principal. There is some anecdotal evidence that their participation actually increase with the swap spread, having an effect of tightening mortgage OAS.

Summing up, we can make the working hypothesis that, as the swap spread widens, dealers, hedge funds and banks will eventually adjust to higher OAS, foreigners will be more aggressive and will settle for a lower OAS, and the agencies should buy at an OAS in line with the core spread. Pension funds and life insurance companies do not change their MBS allocation for swap spread changes; they are silent as to the relation between OAS and swap spread. Last but not least, if the current-coupon MBS OAS drops significantly below the swap spread, borrowers with no foreign exposure can start issuing debt that mimics the MBS in cash flow, paying the MBS OAS, swapping the cash flow with a Euro bank or dealer, and reaping the difference between the swap spread and the OAS. This would drive down the gap between the swap spread and the OAS. Thus, we can assume that the current-coupon OAS would not drop significantly below the swap spread.

In the following, we present some quantitative results that are consistent with this working hypothesis.

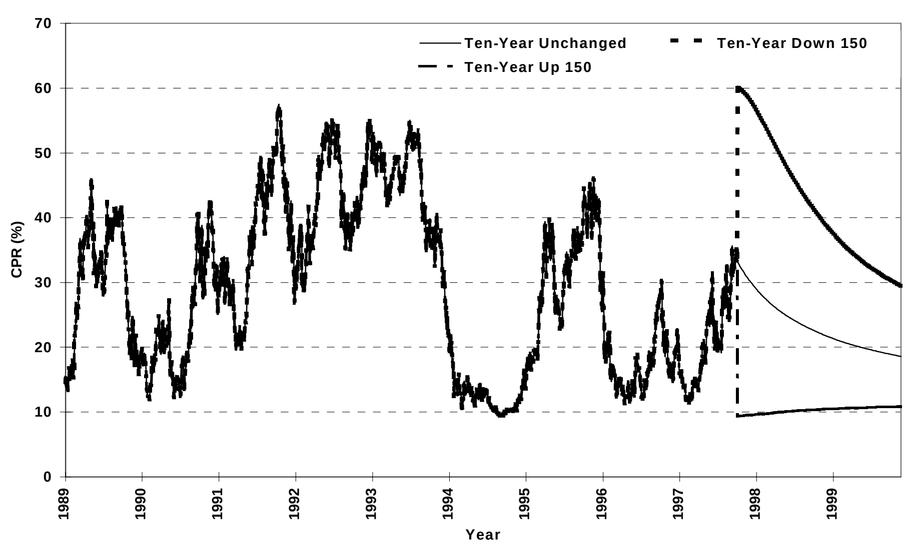
Refinancing is modeled in prepayment models that, along with term structure models, produce the OASs for MBS. That being the case, there seems no reason for refinancing waves to affect the OAS. The fact of the matter is, many investors, as exemplified by mortgage IO buyers, do take a position on the actual prepayment speed. When a tidal wave of prepayments develops and losses are realized, it is small comfort for fund managers to note that the losses had been predicted by the models when the customers are clamoring for the exit. Forced liquidation has the effect of widening the OAS, albeit temporarily, until the panic subsides or until bargain hunters step in.

As the market becomes more sophisticated, this widening of OAS from refinancing wave should be milder and more transient. We will show that the effect is indeed mild and transient but significant.

To mimic the prepayment wave, we define a surrogate for the universe of all mortgage securities. Assume that at any time there is a mix of mortgage coupons and ages. We use a simplified prepayment model to drive the dynamics of this synthetic mortgage universe. More specifically, assume that in the distant past (say, January 1977) there was only one mortgage, at the then prevailing rate. On every day thereafter, given the ten-year Treasury rate, we look up the prepayment rate, both scheduled and unscheduled, from the simple prepayment model. We assume that every prepaid mortgage is refinanced into the prevailing rate, creating a new coupon and changing the mix in the universe.

Figure 6 shows this simulated refinancing wave since April, 1989. Note that the actual history of refinancing waves is available. We opt for the simple proxy made from the history of the ten-year Treasury rate because of its tradability. The simulated prepayment wave is extended beyond November 24, 1977, the day of the study, under three different scenarios of the Treasury rate: no change, up 150bp, and down 150bp (immediate shift and steady thereafter). Note that the response in the mortgage universe prepayment need not be symmetric, and that the strength of the response diminishes as more prepayable coupons are replaced by current coupons. An asymmetric prepayment response would lead to an asymmetric move of OAS with respect to the ten-year rate in the analysis to follow.

Figure 6. Synthetic Prepayment Wave Made From the Ten-Year Treasury Rate



Source: Smith Barney Inc./Salomon Brothers Inc.

The five-year swap spread and the synthetic prepayment wave will be used together for the prediction of OAS level. The OAS series is obtained with the Salomon Smith Barney OAS model with market volatilities for FNMA current coupons. For our purpose, a FNMA current coupon means a combination of the two coupons whose prices straddle par, such that the combination would trade at par.

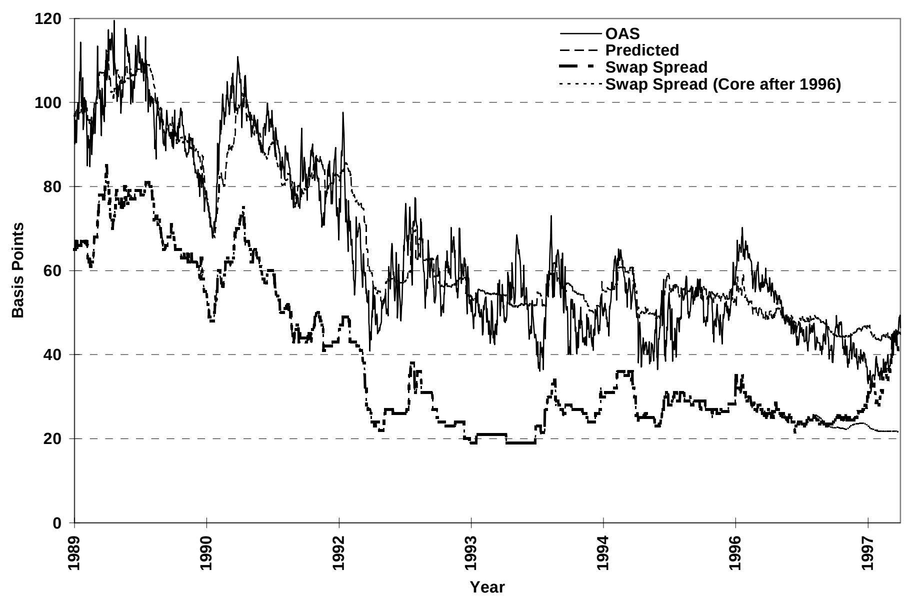
The linear regression results in an R-square of 86%. If in the regression we replace the swap spread after 1996 with the core spread, the R-square improves to 90%.

How would the regression have performed in the past? We did an out-of-sample study going back in time. For each day after January 15, 1990 (when we had 200 data points in the series), we performed first a regression of the OAS on the swap spread, then a regression of the residue on the prepayment wave, always using only data available up to that point. This produces a prediction

OAS = a + b*swap_spread + c*wave + residue.

We furthermore postulate that the residue is mean reverting with a decay rate estimated from the residue series up to that point. The coefficients thus obtained are then used to predict OAS going forward for 240 trading days, using actual swap spreads and the ten-year rates.

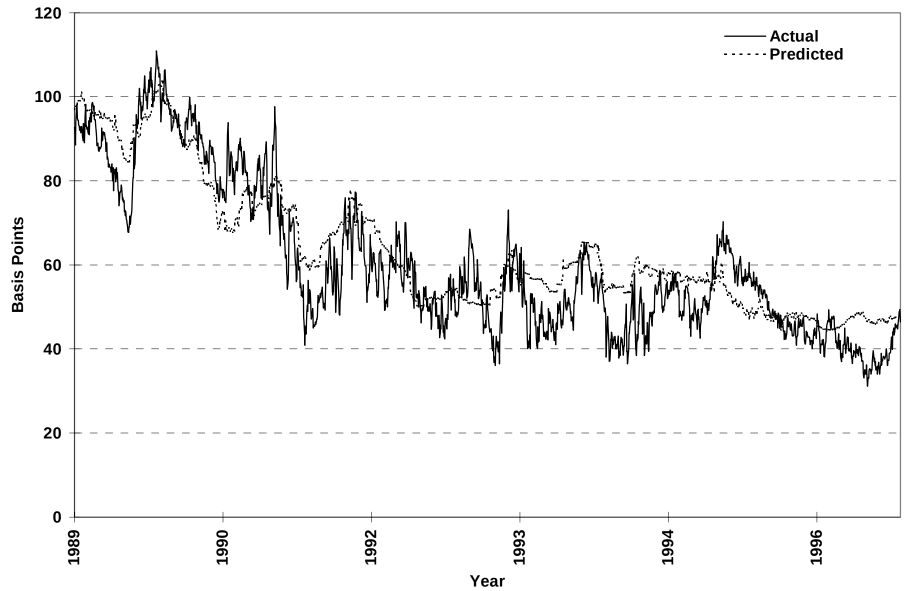
Figure 7. FNMA Current-Coupon OAS Predicted by Swap Spread and Synthetic Prepayment



Source: Smith Barney Inc./Salomon Brothers Inc.

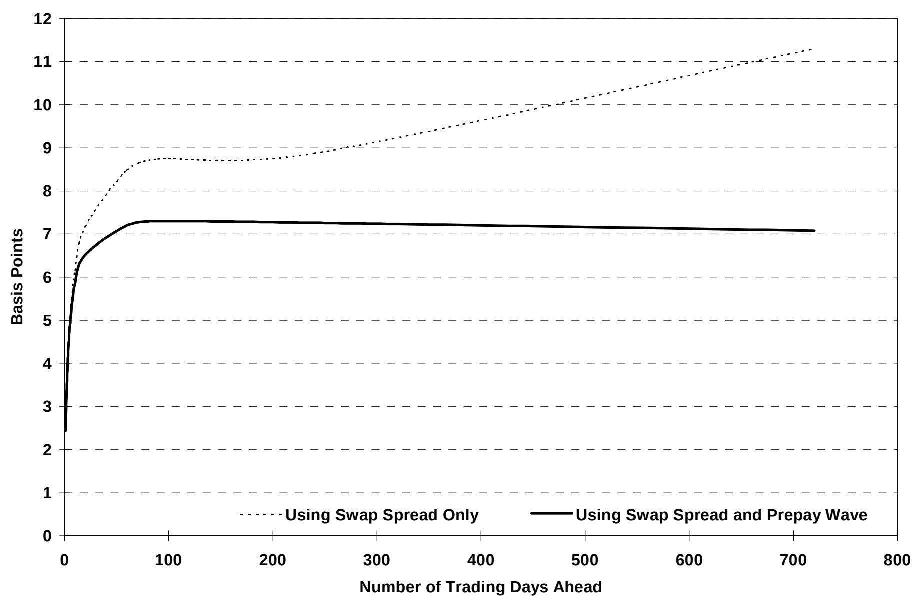
The projected OAS thus produced agrees well with the actual series. Figure 7 shows the predicted OAS series (without the residue) using the synthetic prepayment and the swap spread (with the core swap spread spliced in after 1996). The same graph also shows the swap spread series and the spliced swap spread series. Note that the actual OAS had a downward trend in 1997 until it hits the swap spread; this is consistent with our earlier observation about the latter serving as a floor for the former. The 240-day prediction using the swap spreads and the synthetic prepay wave is plotted against the actual OAS levels in Figure 8. The RMSE for the forward prediction scheme is plotted in Figure 9.

Figure 8. Predicting the OAS 240 Trading Days Ahead, Using Swap Spread and Prepay Wave



Source: Smith Barney Inc./Salomon Brothers Inc.

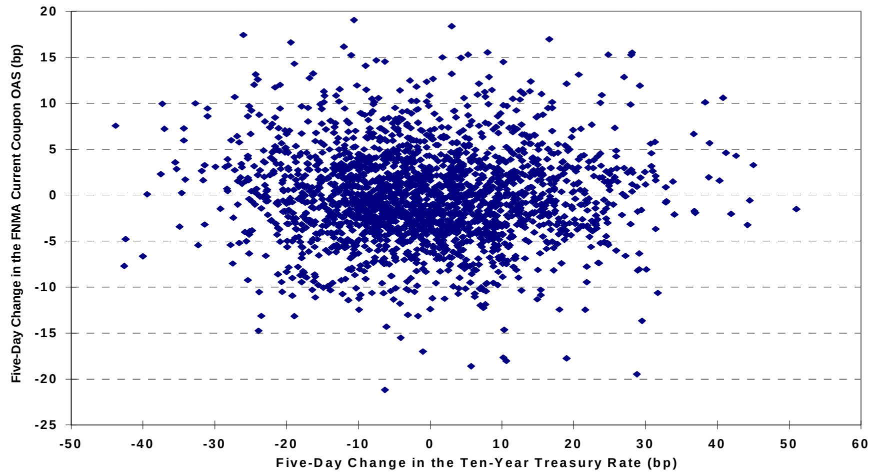
Figure 9. RMS Error of Forward OAS Prediction with Swap Spread and Ten-Year Treasury



Source: Smith Barney Inc./Salomon Brothers Inc.

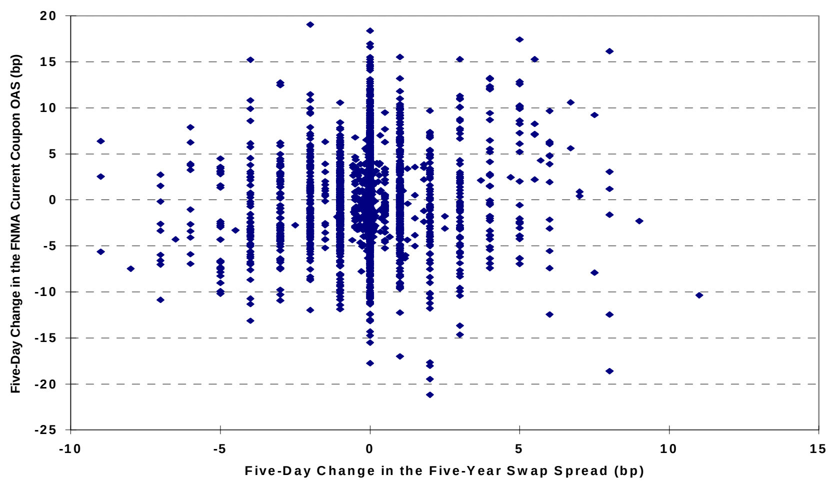
In Figures 10-13 we plot the scatter diagram of the five-day moves in the OAS against moves in the ten-year rate, the swap spread, the prepay wave, and the benchmark predictor using both the swap spread and the prepay wave. There is no discernible correlation with OAS in any of these predictors. However, when we look at 20-day moves, Figure 17 shows a clear trend: when the benchmark predictor widens, it is more likely that the actual OAS would widen, and vice-versa. Figure 18 shows an even stronger correlation when we look at a horizon of 60 trading days. The conclusion is that over and above interest rate and volatility hedges, hedging (and rebalancing) with this benchmark is useful in controlling the risk in mortgages due to OAS fluctuation, even though its effect is noticeable only after some 20 trading days.

Figure 10. Five-Day Moves in OAS Versus Five-Day Moves in the Ten-Year Rate



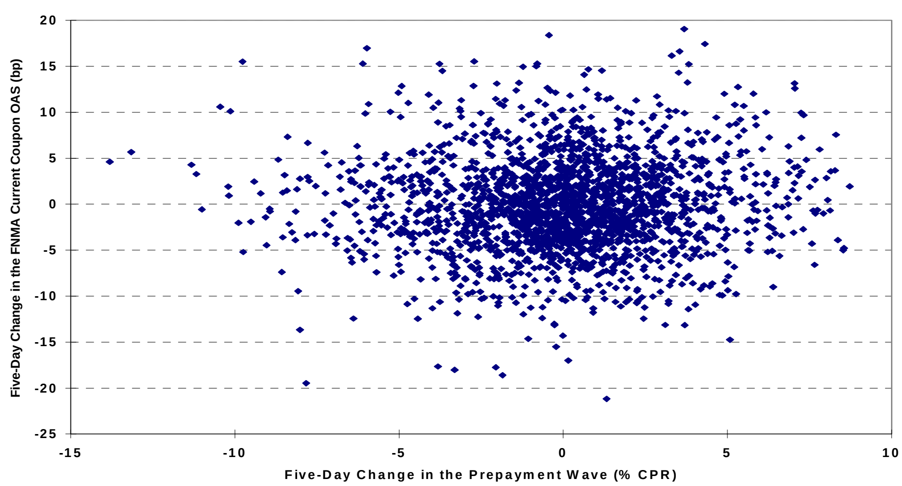
Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 11. Five-Day Moves in OAS Versus Five-Day Moves in the Swap Spread



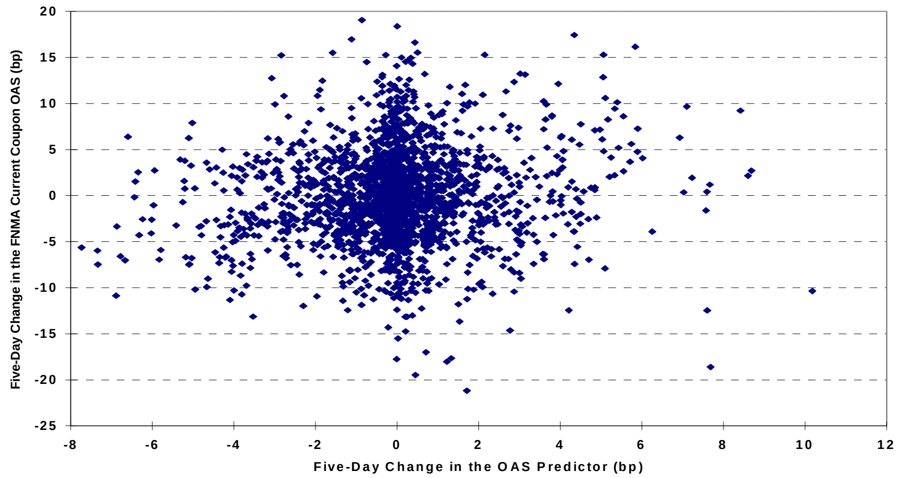
Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 12. Five-Day Moves in OAS Versus Five-Day Moves in the Synthetic Prepayment Wave



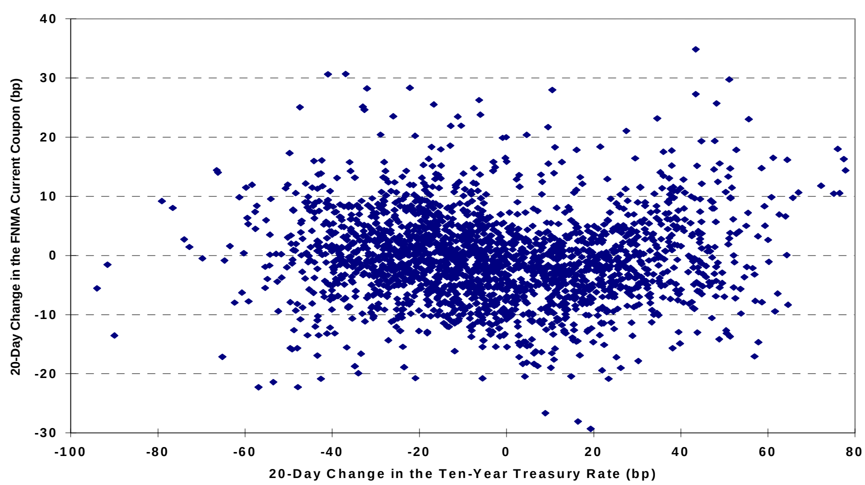
Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 13. Five-Day Moves in OAS Versus Five-Day Moves in the Benchmark OAS Predictor



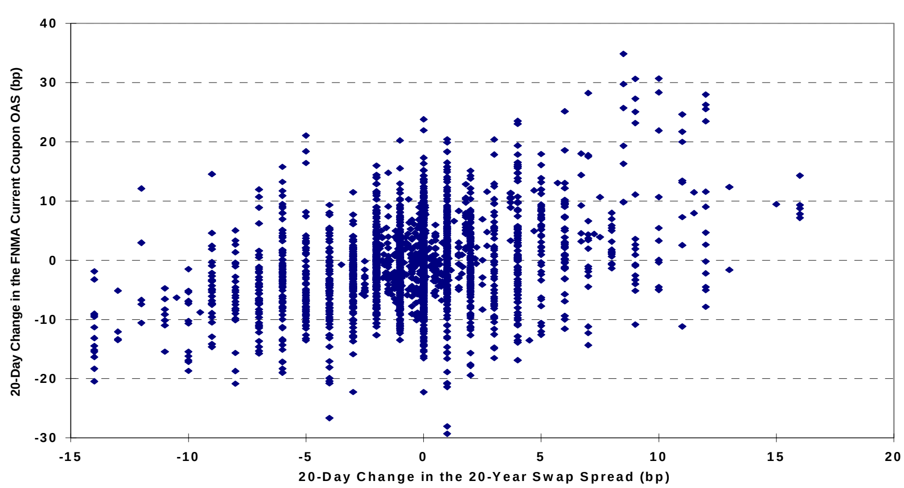
Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 14. Twenty-Day Moves in OAS Versus 20-Day Moves in the Ten-Year Rate



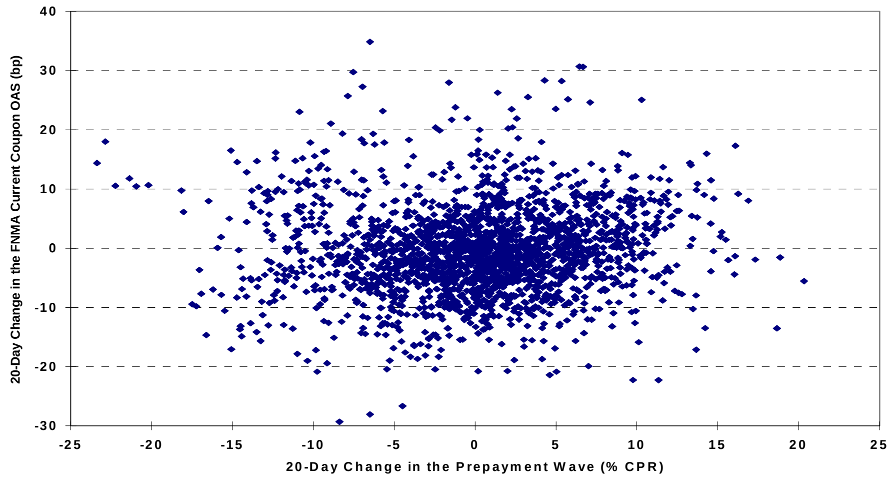
Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 15. Twenty-Day Moves in OAS Versus 20-Day Moves in the Swap Spread



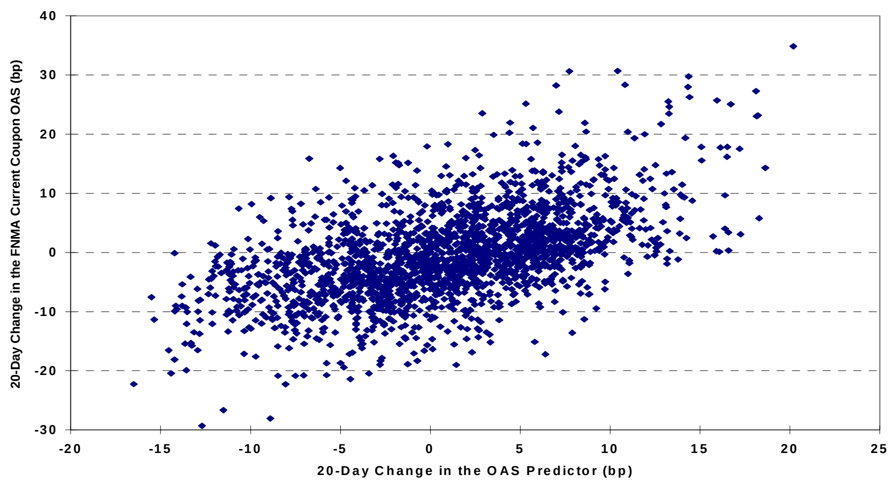
Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 16. Twenty-Day Moves in OAS Versus 20-Day Moves in the Synthetic Prepayment Wave



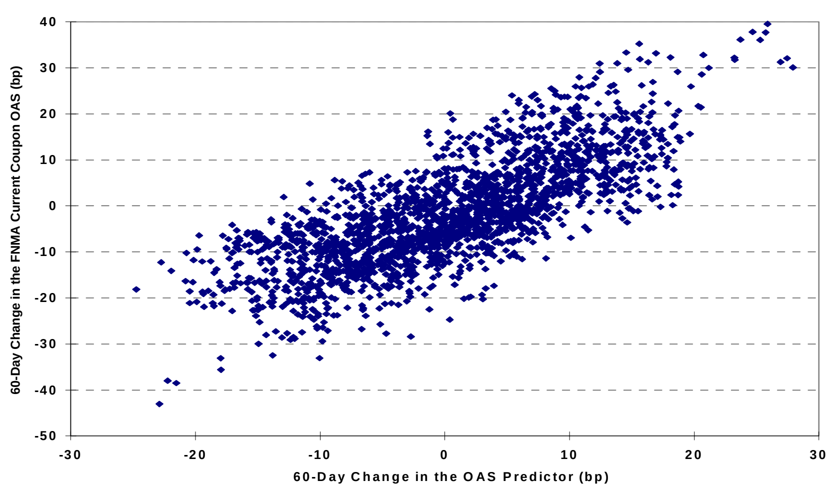
Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 17. Twenty-Day Moves in OAS Versus 20-Day Moves in the Benchmark OAS Predictor



Source: Smith Barney Inc./Salomon Brothers Inc

Figure 18. Sixty-Day Moves in OAS Versus 60-Day Moves in the Benchmark OAS Predictor



Source: Smith Barney Inc./Salomon Brothers Inc.

As of November 24, 1997, the regressions described in the above sections produce the following formulas:

Core swap spread = S_o = exp(-0.325X + 0.254Y - 2.98)*100bp

"Fair OAS" = OAS_o =1.096*swap spread+0.166*wave + 15.7bp

Actual OAS = OAS_o + residue

We also find that the residue decays at a rate of 0.926 per trading day. Going forward, then, the predicted OAS is obtained by the following steps.

1. Project the exchange rates. The mortgage investor may feel uneasy about this unconventional benchmark. A simple alternative is to assume that the exchange rates will maintain the current level.

2. For the projected value of the exchange rates, calculate the value of C, the weighted one-month moving average of the exchange rates, $\overline{C}$ the three-year moving average of C, and the dollar momentum $X = C - \overline{C}$

3. Project the five-year Treasury rate and its six-month moving average Y.

4. Calculate the core swap spread using the formula furnished above.

5. Project the ten-year Treasury rate and the prepayment wave.

6. Calculate the fair OAS using the formula above.

7. Project the residue by using its current value decayed at a rate of 0.926 per trading day.

8. Predict the OAS with the maximum of the swap spread and the sum of the fair OAS and the decayed residue calculated in steps (6) and (7).

Before proceeding, we note that the effect of the prepayment wave is rather mild. The latter ranges from 10 CPR to 60 CPR, approximately (see Figure 6). With the coefficient of 0.166, the contribution to the fair OAS can vary by only 0.166*50 = 8.3bp. Furthermore, Figure 6 shows that the effect is transient.

We also note that the effect of the swap spread on the OAS in the past (and that of the core swap spread in the future) is approximately 1.1 to 1. The reader can verify that the OAS predicted by the formulas and prediction steps above remains in reasonable ranges when the dollar momentum and Treasury rates move to extreme levels.

As an example, Figure 19 shows the level of the various variables on November 24, 1997.

Figure 19. Levels as of November 24, 1997

Variable	Level
Weighted Exchange Rates	7.575
One-month moving average C of Weighted Exchange Rates	7.527
Three-year moving average $\overline{C}$ of Weighted Exchange Rates	7.143
Dollar momentum $X = C - \overline{C}$	0.384
Six-month moving average Y of the five-year Treasury rate	6.174%
Core Swap Spread S_o	21.6bp
Actual Swap Spread S	40.5bp
Synthetic Prepay Wave W	33.26CPR
Fair OAS	44.9bp
Actual OAS	46.4bp
Residue	1.5bp

Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 20 shows the projected prepayment wave going forward when the Treasury curve is subject to various shocks and then held steady.

Figure 20. Synthetic Mortgage Universe Prepayment in CPR (W=33.3 on 24 Nov 97)

Scenario	Day1	Day5	Day30	Day90	Day365
ΔY=+150bp	9.3	9.4	9.4	9.6	10.4
+100bp	11.0	11.0	11.1	11.5	12.2
+ 50bp	17.7	17.7	17.5	17.3	16.2
0bp	33.1	32.9	31.6	29.1	22.5
- 50bp	50.2	49.8	47.6	43.1	29.0
-100bp	58.4	58.1	56.0	51.3	33.6
-150bp	60.2	60.1	59.4	56.7	41.0

Source: Smith Barney Inc./Salomon Brothers Inc.

In Figure 21, we show the effect on X from shocks to the exchange rates, with the dollar gaining or losing 10% of its current value relative to the other major currencies.

Figure 21. Scenario of Dollar Momentum X (X=0.384 on 24 Nov 97)

Scenario	Day1	Day5	Day30	Day90	Day365
Dollar gains 10%	0.397	0.542	0.857	1.054	0.852
No change	0.385	0.392	0.403	0.396	0.310
Dollar loses 10%	0.373	0.241	-0.051	-0.263	-0.233

Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 22 combines these scenarios of X and W to project the OAS levels.

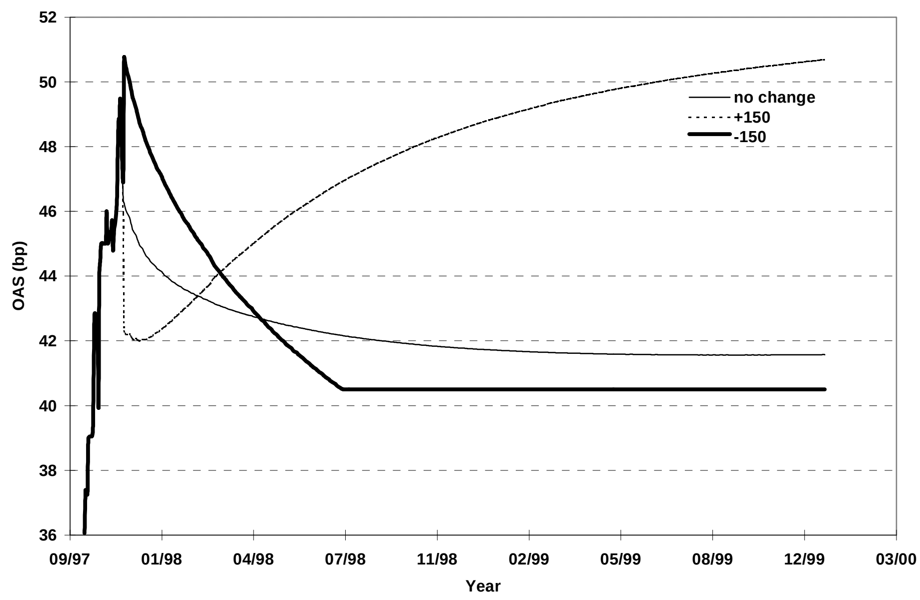
Figure 22. Scenario OAS (OAS=46.4bp on 24 Nov 97)

Scenario			Day1		Day5		Day30		Day90		Day365	
ΔY	Δ Swap Spread	Dollar gains	Fair OAS	Proj OAS	Fair OAS	Proj OAS	Fair OAS	Proj OAS	Fair OAS	Proj OAS	Fair OAS	Proj OAS
+150bp	0bp	0	42.3	42.3	42.2	42.2	42.1	42.1	43.7	43.7	48.5	48.5
+100	0	0	42.6	42.6	42.4	42.4	41.9	41.9	42.7	42.7	45.6	45.6
+50	0	0	43.7	43.7	43.4	43.4	42.6	42.6	42.5	42.5	43.3	43.3
0	0	0	46.3	46.3	45.8	45.8	44.4	44.4	43.3	43.3	41.8	41.8
-50	0	0	49.1	49.1	48.5	48.5	46.7	46.7	44.5	44.5	40.5	40.5
-100	0	0	50.5	50.5	49.8	49.8	47.6	47.6	44.8	44.8	39.2	40.5
-150	0	0	50.8	50.8	50.0	50.0	47.8	47.8	44.7	44.7	38.6	40.5
0	+20	0	46.3	60.5	45.8	60.5	44.4	60.5	43.3	60.5	41.8	60.5
0	+10	0	46.3	50.5	45.8	50.5	44.4	50.5	43.3	50.5	41.8	50.5
0	-10	0	46.3	46.3	45.8	45.8	44.4	44.4	43.3	43.3	41.8	41.8
0	-20	0	46.3	46.3	45.8	45.8	44.4	44.4	43.3	43.3	41.8	41.8
0	0	+10%	46.2	46.2	44.7	44.7	41.3	41.3	38.9	40.5	38.2	40.5
0	0	-10%	46.3	46.3	47.0	47.0	48.1	48.1	48.7	48.7	46.1	46.1

Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 23 graphs the projected OAS when the Treasury rates are subject to +150bp and -150bp shocks. In the case of a -150bp shock, the OAS first widens 4.5bp, and then, as the prepayment wave wears itself out, tightens back past the initial level because the more favorable business environment will lead to lower core swap spreads. Eventually, the (full) swap spread provides a floor to the tightening. In the other directions, when the Treasury rates jump by +150bp, the OAS first tightens approximately 4bp but eventually widens as a result of the harsher environment and the widening core swap spread. The initial OAS changes in these two scenarios are almost equal. That is because the current level of the synthetic prepayment W is at just about the mid point of the extreme values. If the initial prepayment level were at, say, 10 CPR, then those OAS changes would be very asymmetric.

Figure 23. Projected Scenario OAS for Shifts in the Treasury Rates, 24 Nov 97



Source: Smith Barney Inc./Salomon Brothers Inc.

Note from Figure 22 that with the current swap spread at 40.5bp and the current OAS at 46.4bp, a 5.9bp increase in the former would activate it as a floor for the latter, and any further increase would be reflected in the same increase in OAS, according to our model.

1. The swap spread consists of two components. The core reflects fair spread for borrowers who have no exposures outside the United States. Superimposed on this are credit risks due to discrete events, the most recent of which being the Asian turmoil.

2. The recent tightening of mortgage OAS, to almost even with the swap spread, is mainly due to the latter's widening because of the Asian risk.

3. Historically, the OAS is predicted well with the prepayment wave and the swap spread.

4. The performance of the predictor for the recent past is preserved provided that we use the core swap spread in this recent period and until the recent Asian economical crisis blows over.

5. Projected OAS changes can be incorporated in the hedging of a mortgage portfolio. Historical data show that the uncertainty can be reduced on the average, when the portfolio is managed for more than 20 days.

6. Investors who are uncomfortable with using currency hedges can specialize the model by projecting constant exchange rates (for the major currencies) going forward.

7. The prepayment wave effect will be mild and transient.

8. When the OAS is near the swap spread, a bearish condition exists for mortgages because the latter serves as a floor for the OAS (although sometimes unjustly so, since mortgages should not be subject to non-US risks, which is a component of the swap spread).

The above conclusions are subject to some cautionary remarks. The fact that the regression procedure passes one significance test, as shown in the appendix, does *not prove* that a correlation exists between the variables. In particular, the future may look very different. In particular, if the agencies become more agressive, or as other investors develop cheaper financing vehicles, a gradual tightening trend can develop for mortgage OAS.

In section III, we regressed one time series, Z=log(sw5), on two others, X and Y. One question is whether the series contain large enough samples for a regression on levels, as opposed to one on daily changes, to be meaningful.

We will show that the level of R-square in our regression is indeed significant in the context of time series having the spectral characteristics as the three given ones.

To be precise, we assume that each series is an observation of a Gaussion process with the same spectral characteristics as the observed series. Consider the spectral representation (Fourier transform[8]) of a series discretized as N equally spaced data points:

$$X(j)=\sum_{k=o}^{N} x_k \exp(i2\pi kj/N) \qquad (j=0,...,N)$$

The coefficients x are in general complex, but the complex conjugate of x_{N-k} must equal x_k because the series X(j) is real. Then the Gaussian process $\tilde{X}$ is obtained by multiplying each of the coefficients with a complex normal random variable u with mean 0 and variance 1. The complex conjugate of u_{N-k} is equal to u_k, but the random variables u are otherwise mutually independent. Thus,

$$\tilde{X}(j)=\sum_{k=0}^{N} x_k u_k \exp(i2\pi kj/N) \qquad (j=0,...,N)$$

Any observation of $\tilde{X}$ would have the same look and feel as the original series X; intuitively, it is what X "could have been."

With the three given series X, Y and Z, there thus correspond three Gaussian processes. Any triple of observations of these three Gaussian processes can be subject to the linear regression, producing an observed R-square. We could calculate the probability that the observed R-square is as high as the level for the original series, 0.82 in our case. As a null hypothesis, assume that the three Gaussian processes are independent. Since the three Gaussian processes are assumed independent, the R-square from them is spurious, and a high calculated probability means that the detected level is not statistically significant. Figure 24 lists the sample distribution for various R-square levels. (Instead of calculating the probabilities, we use Monte Carlo to estimate them; 10000 triple random samples are made of the three Gaussian processes, regression performed, and the statistics of the resulting R-squares tallied.) It shows that the detected level of 0.82 is highly significant; the probability of false detection at that level being lower than 0.2%.

Figure 24. Sample Distribution of R-Square in the Regression of the Three Time Series (10000 Sample Runs)

Level of R-Square	Probability of Obtaining a Higher R-Square
0.40	0.237
0.50	0.121
0.60	0.052
0.70	0.016
0.80	0.002

Source: Smith Barney Inc./Salomon Brothers Inc.

We note that an observed R-square level of 0.40 would not be significant, the probability of a spurious detection of such a level is almost one in four.

[8] See "Numerical Recipes in C" by W.H. Press et.al., Cambridge University Press, 1992.

ADDITIONAL INFORMATION AVAILABLE UPON REQUEST

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