Collateralized Mortgage Obligations (CMOs) were invented to broaden the appeal of mortgage-backed securities by creating a wide range of duration and prepayment profiles out of basic mortgage pass-through cash flows. CMOs are created by redistributing the cash flows generated by the underlying collateral based on predefined rules. The collateral can be agency pass-through pools, whole loans, or even other CMO bond classes.

The objective of this primer is to explain the various alternatives available for structuring principal and interest payments of mortgage bonds and to gauge and compare risks in the resulting bond classes. For each individual structure that we study we look at the average life variability and option-adjusted characteristics of the constituting bond classes.
I. INTRODUCTION

Collateralized Mortgage Obligations (CMOs) were created to broaden the appeal of mortgage-backed securities by creating a wide range of duration and prepayment profiles out of basic mortgage pass-through cash flows. CMOs are created by redistributing the cash flows generated by the underlying collateral based on predefined rules. The collateral can be agency pass-through pools, whole loans, or even other CMO bond classes.

Before the CMO market took off, investors usually obtained exposure to the mortgage market using MBS pass-throughs where investors share the principal and interest payments on the underlying loans on a pro-rata basis. However, pass-throughs are not suitable for some institutional investors because a change in prepayments may result in a mismatch between their funding and liabilities. For instance, banks and other financial institutions often wish to lock in a spread over their cost of funds. The duration of most fixed-rate pass-throughs does not match the duration of the short-term liabilities of these institutions. In addition, even if the durations of mortgage pass-through assets and bank/financial institution liabilities match initially, mortgages can extend substantially in a rates back up and create a duration mismatch between the assets and liabilities of a bank. Thus, banks are often concerned about the extension risk in mortgage pass-throughs. On the other hand, insurance companies and pension funds have their liabilities spread over several years. These institutions are predominantly concerned about the contraction risk in mortgage pass-throughs because in times of heavy refinancings, their assets will shorten substantially although the duration of their liabilities remains almost unchanged. Thus, some institutional investors are more concerned about extension risk while others are more concerned about contraction (call) risk.

CMO structuring distributes cash flows of the underlying mortgage collateral to different tranches of a deal. Each tranche will have prepayment exposures that are different from those of other tranches and the underlying collateral. Individual tranches may offer widely different spreads to compensate investors for the risk exposures of individual bonds. It is worth emphasizing that CMO structures do not eliminate the call/extension risk of the underlying collateral – they simply redistribute this risk among the different tranches of a CMO structure.

Recent Issuance Trends

Figures 1 and 2 provide a breakdown of the historical growth of the Agency CMO market and the level of issuance activity, respectively. Since its inception in June 1983 with the issuance of the first CMO by Freddie Mac, the CMO market has experienced significant growth and innovation. The Agency CMO market currently consists of over $1 trillion in outstanding securities making it one of the largest sectors in the fixed-income universe. CMOs issued by Freddie Mac and Fannie Mae make up roughly ninety percent of the Agency market with the remaining ten percent attributable to Ginnie Mae.

The overall level of agency issuance usually tracks mortgage rates with the highest levels of issuance corresponding to periods of heavy refinancing activity. Other important factors that determine CMO issuance are: the slope of the yield curve, valuations of pass-throughs relative to CMO bonds, “specialness” of dollar rolls, and the special needs of some large participants in the MBS market (e.g. GSEs and overseas investors). In general, CMO issuance tends to be heavier in environments where dollar rolls are trading at carry and the yield curve is steep.

The types of CMO structures created at any time are highly dependent on market conditions and investor preferences. For example, demand for high yielding support structures drove
CMO deals for most of the last 2-3 years. This occurred because investors were willing to buy high-yielding support structures with high negative convexity in an environment characterized by low volatility and low yields. Similarly, demand for floaters drove CMO deals in the summer of 2006 when the 10-year Treasury yield backed-up above 4.75% and several domestic banks, money managers and overseas investors preferred to buy floaters instead of fixed-rate bonds.

**Figure 1: Outstanding Volume of Agency CMOs**

![Graph showing outstanding volume of Agency CMOs from 1987 to 2006 Q2](image)

Source: Banc of America Securities

**Figure 2: Annual Issuance of Agency CMOs**

![Graph showing annual issuance of Agency CMOs from 1988 to 2006 YTD](image)

Source: Banc of America Securities

**The Evolution of CMO Structures**

In terms of innovation, CMOs have evolved from simple sequential structures based on principal pay down rules alone to more complex multiple-redemption schedules built by redistributing principal as well as interest cash flows on the underlying collateral. Thus, although initial CMO structures were mainly concerned with reallocation of call/extension...
risk, current CMO structures allow investors to express a view on prepayments, shape of the curve and volatility changes as well. Figure 3 provides a summary of various commonly used structuring methods for slicing up the cash flows on mortgage collateral. Some of these structuring methods can be applied to the cash flows of the pass-through collateral backing the deal itself, or to the cash flows of a specific tranche in the deal.

Figure 3: Methods For Creating CMOs

<table>
<thead>
<tr>
<th>Cash-flow Structuring Method</th>
<th>Examples</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct transfer of Cashflows</td>
<td>Passthrough</td>
<td>The simplest security; most common in non-agency CMOs</td>
</tr>
<tr>
<td>Sequential allocation of principal</td>
<td>Sequentials</td>
<td>Creates securities with a wide range of average lives</td>
</tr>
<tr>
<td>Allocation of principal depending on prepayment speeds</td>
<td>PACs, TACs, Companions</td>
<td>Creates tranches with more or less average life variability than collateral</td>
</tr>
<tr>
<td>Allocation of interest to pay principal</td>
<td>Z-bonds, VADMs</td>
<td>Increases the average life stability across the structure while increasing duration on the accrual tranche</td>
</tr>
<tr>
<td>Allocation of interest versus principal</td>
<td>IOs, POs</td>
<td>Creates tranches with strong directionality with respect to interest rates</td>
</tr>
<tr>
<td>Indexing of coupon payments</td>
<td>Floaters and Inverse floaters</td>
<td>Creates securities that are sensitive to both short-term factors (index changes) and long-term factors (prepayment rates)</td>
</tr>
</tbody>
</table>
II. BASIC CMO STRUCTURES

In this section we will take a look at some of the basic CMO structures created by structuring the principal and interest payments of the underlying collateral. Since the primary objective of structuring cash flows in a CMO is to tailor duration and prepayment risks, variability in both the average life and window size of a tranche with respect to changes in prepayment assumptions are important measures in assessing the characteristics of a CMO tranche.\(^1\) The variability in the average life and window size of a CMO tranche stems from its share of the prepayment option embedded in the underlying collateral. Option-adjusted spreads (OAS), which summarize the embedded optionality in a bond, are consequently the most widely used tool in analysing CMO structures. We will use the variability of average life and window sizes and OAS as our primary tools for assessing the CMO structures presented below.

1. Structuring Principal Cash Flows

Sequential, PACs, and TACs are some of the most common CMO structures that are created by structuring the principal payments of the underlying mortgage pools. We discuss these structures in detail below.

1.1 Sequential Structures

Segmenting the principal payments into different average-life securities, called classes or tranches, that are retired sequentially creates Sequential. All principal payments are directed to the class with shortest maturity (Class A) until it is completely paid off. The principal payments are then routed to the class with next shortest maturity (Class B) and so on. The average-lives are calculated at a constant prepayment speed assumption, known as the pricing speed, and are therefore subject to uncertainty arising from the prepayment risk of the underlying collateral. All sequentials will undergo extension or shortening depending on whether actual prepayments are slower or faster than the pricing speed. Figure 4 shows the variability in the payment behavior of a hypothetical four-tranche sequential, with an original pricing speed of 225% PSA, at three different prepayment speeds.

Figure 5 shows the variability in the average-lives and window sizes for the four tranches over a wide range of prepayment speeds. The weighted-average life (WAL) comparison of the different sequential tranches demonstrates that the prepayment risk of the underlying collateral is distributed unevenly among different tranches. Thus, for example, we see that tranches B and C exhibit highest variability in their WALs relative to their original WALs based on the pricing speed of 225% PSA. Furthermore, note that a change in the prepayment speed assumption not only extends/shortens the size of the payment window but also significantly alters its start time for the later tranches. Therefore, as a result of sequential amortization imposed by the structure, the length of time before a sequential starts amortizing (the lockout period) is also subject to uncertainty or lockout period risk.

\(^1\) The window size or length of the payment window of a tranche represents the time span between the first and the last principal payments on the security. The average life of a tranche is the weighted-average time until its principal is paid for a given prepayment speed.
The variability in the payment window size and the length of the lockout period for different sequential classes can be seen in the lower part of Figure 5, where the width of a colored region for a given prepayment speed represents the payment window size in years for the corresponding sequential, and the cumulative width of all colored regions underneath that represent the length of the lockout period.

The option-adjusted parameters calculated at zero OAS for a current coupon four-tranche sequential structure are presented in Figure 6. Notice that the first and the last tranches carry
lower option costs as compared to the middle two tranches. Since the tranches must add up to the collateral, the underlying collateral contributes very significantly to a CMO’s risk/return characteristics. We illustrate this point in Figure 7 by changing the underlying collateral for our four-tranche sequential to an MBS pass-through with a 6% net coupon. Increasing the coupon shortens duration for all tranches but at the same time increases the convexity and option cost for the middle tranches to match the overall increased convexity and option cost of the “in-the-money” collateral. Similarly, changing other collateral characteristics of the underlying pools like WAC and WAM will also be passed through to the CMO bonds.

**Figure 5: WAL and Window Size Variability in a Sequential Structure**

![Graph showing WAL and Window Size Variability](image)

Source: Banc of America Securities

**Figure 6: Relative Value Indicators for a Current Coupon Four-Tranche Sequential**

<table>
<thead>
<tr>
<th>Bond Characteristics</th>
<th>Option Cost</th>
<th>Eff. Duration</th>
<th>Eff. Convexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Year Sequential</td>
<td>63</td>
<td>0.6</td>
<td>-2.5</td>
</tr>
<tr>
<td>4-Year Sequential</td>
<td>81</td>
<td>3.0</td>
<td>-2.4</td>
</tr>
<tr>
<td>8-Year Sequential</td>
<td>68</td>
<td>6.6</td>
<td>-1.6</td>
</tr>
<tr>
<td>18-Year Sequential</td>
<td>42</td>
<td>10.1</td>
<td>-1.3</td>
</tr>
<tr>
<td>Collateral Net Coupon 5%; WAC 5.6%; WAM 356; WAL 6.8</td>
<td>62</td>
<td>4.6</td>
<td>-2.0</td>
</tr>
</tbody>
</table>

Source: Banc of America Securities
Figure 7: Effect of Changing the Collateral on the Risk Characteristics of CMOs

<table>
<thead>
<tr>
<th>Bond Characteristics</th>
<th>Option Cost</th>
<th>Eff. Duration</th>
<th>Eff. Convexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Year Sequential</td>
<td>47</td>
<td>-0.8</td>
<td>-1.8</td>
</tr>
<tr>
<td>4-Year Sequential</td>
<td>84</td>
<td>-0.4</td>
<td>-4.7</td>
</tr>
<tr>
<td>8-Year Sequential</td>
<td>110</td>
<td>2.9</td>
<td>-4.0</td>
</tr>
<tr>
<td>18.8-Year Sequential</td>
<td>72</td>
<td>7.4</td>
<td>-1.4</td>
</tr>
<tr>
<td>Collateral</td>
<td>93</td>
<td>1.8</td>
<td>-2.9</td>
</tr>
</tbody>
</table>

Source: Banc of America Securities

1.2 Planned Amortization Classes (PACs)

PACs protect against both the extension and the call risk within a defined range of prepayment speeds. This is accomplished by assigning PAC bonds a principal redemption schedule and then redirecting any excess or shortfall in the monthly cash flows to support tranches called companions. The principal redemption schedule of PACs is created by overlaying the redemption schedules based on two specific prepayments speeds (“PAC bands”). The overlapping area bounded by the two redemption schedules defines the PACs redemption schedule. This is illustrated in Figure 8, where we have selected the PAC bands at 100% PSA and 250% PSA. The redemption schedules based on these two speeds are drawn and the common area (represented by the Region I) represents the principal redemption schedule for the PACs. Now if the collateral prepays at any constant prepayment speed that falls within the two PAC bands the PAC redemption schedule will be met. However, if the collateral prepays at varying speeds overtime, even if the speeds remain within the PAC bands, the redemption schedule may be violated.

Figure 8: Creating a PAC Structure (PAC Band of 100% - 250% PSA)

Source: Banc of America Securities

To provide adequate protection to the PAC bond against extension as well as call risk, at the time of CMO issuance, the upper and lower PAC bands are normally set well above and below the expected long term prepayment rate on the underlying collateral respectively. Widening the PAC bands can further enhance the protection. However, widening the PAC bands reduces the amount of PACs available in the structure with a corresponding increase in the companions.

The PAC bond can be divided sequentially much like a sequential structure into PAC classes. Creation of these sequential PAC classes means that for the shorter maturity PAC classes the
The actual range of prepayment rates over which a particular PAC can remain on its payment schedule becomes wider than the original PAC bands. This occurs because under the prepayment scenarios that exceed the original upper PAC band, companions may still be outstanding during the amortization phase of shorter weighted-average life PAC classes but may not exist to support the longer maturity PAC classes. These new protected ranges, called effective PAC bands, are widest for the PAC class with shortest WAL in the structure and narrow down with the sequential order of the PAC classes.

Figure 9 shows principal payment schedules for the four PAC classes created out of the PAC structure with PAC bands of 100% PSA to 250% PSA as shown above in three different prepayment scenarios i.e., 125% PSA, 175% PSA and 225% PSA. Notice that all the PAC classes meet their original redemption schedules under all the three scenarios since the collateral prepayment speeds fall within the PAC bands. The effects of slower or faster prepayments are solely born by the companions, which extend when prepayment speeds fall and contract when speeds rise.

**Figure 9: Projected Principal Payments for a PAC-Structure at Selected PSAs**

Source: Banc of America Securities
Next, we have chosen a constant prepayment speed of 300% PSA to show what happens when the collateral prepay at a speed outside the PAC band. In this case, one would expect the PAC schedules to “bust.” However, due to the fact that for short PACs the effective PAC bands are wider than the original PAC bands, even at 300% PSA the schedule departures occur only for the longer PACs (PAC C and PAC D), as illustrated in Figure 10.

**Figure 10: Cash Flows to a PAC Structure at Speeds Above the Upper Band**

PACs are relatively more stable than some of the other structures that we have discussed so far. To demonstrate this, we compare the WAL profiles of three comparable bonds in Figure 11. As compared to the tranche B from the standard sequential structure, PAC B has a flat WAL profile over the effective PAC band and continues to dominate the standard tranche B even beyond this range on either side. The PAC’s stability comes at the expense of the companion which exhibits a much higher variation of WAL. Finally, the option-adjusted characteristics of the PACs are shown in Figure 12. Similar to sequential structures, the first and the last PAC tranches have lower option cost as compared to the intermediate tranches.

**Figure 11: WAL Comparison of Sequential, PAC and Support Bonds**

Source: Banc of America Securities
Figure 12: Relative Value Indicators for a PAC Structure

<table>
<thead>
<tr>
<th>Bond Characteristics</th>
<th>Option Cost</th>
<th>Eff. Duration</th>
<th>Eff. Convexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9-Year PAC A</td>
<td>35</td>
<td>0.8</td>
<td>-1.3</td>
</tr>
<tr>
<td>3.9-Year PAC B</td>
<td>53</td>
<td>1.3</td>
<td>-0.7</td>
</tr>
<tr>
<td>7.9-Year PAC C</td>
<td>60</td>
<td>3.6</td>
<td>-3.1</td>
</tr>
<tr>
<td>17-Years PAC D</td>
<td>44</td>
<td>7.9</td>
<td>-2.7</td>
</tr>
<tr>
<td>5-Years Companion</td>
<td>89</td>
<td>7.7</td>
<td>-1.0</td>
</tr>
<tr>
<td>Collateral</td>
<td>62</td>
<td>4.6</td>
<td>-2.0</td>
</tr>
</tbody>
</table>

Source: Banc of America Securities

1.2.1 PAC Band Drift
Effective PAC bands drift over time as a result of changes in collateral balance and relative outstanding balances of PACs and companions. The direction in which the PAC bands drift depends upon the level of prepayments in relation to the current PAC bands. Note that the PAC band drift occurs even when prepayment speeds stay within the initial PAC bands. When prepayment speeds are within the bands, both the upper and lower PAC bands drift upwards. The upper PAC band shifts upwards because prepayments are lower than upper band implying that more companions would be available to support PACs in future. However, since prepayments exceed lower PAC band, the lower PAC band drifts upward indicating that if prepayments slow down in future fewer principal cash flows would be available due to more depleted collateral to keep the PAC on schedule.

If prepayments are faster than the upper band, early amortization of companions forces the upper band of the PAC to move downwards. However, the lower band shifts upwards in this scenario causing the two bands to converge.

Finally, if prepayments are below the current lower PAC band, both PAC bands rise but the currently paying PAC does not pay as per schedule. In this case a higher future prepayment rate is required to restore the PAC schedule.

1.2.2 Different Types of PACs
For investors who are willing to trade off some prepayment protection for higher yield, a second PAC structure, called Type II PAC, can be created out of the companions in a standard PAC structure. A narrower set of PAC band than the standard PAC is chosen for creating the Type II PAC structure. Similar to a regular PAC, a Type II PAC pays as per its set redemption schedule as long as prepayments stay within its PAC bands. However, if faster prepayments erode companions before the complete amortization of the standard PAC, the Type II PAC acts like a companion to support the standard PAC.

Another variation is called the super/subordinate PAC structure, which instead of creating a second PAC structure with narrower bands divides a standard PAC into senior and subordinate tranches. The available principal payments are allocated sequentially to the super PACs, then to the subordinate PACs and finally to the companions. If after making the schedule payments, principal is still available then it is allocated to the above classes in the
reverse order. The super PAC tranches enjoy wider effective protection bands through additional support from the subordinate PACs.

1.3 Targeted Amortization Classes (TACs)

TACs are bond classes, which like PACs, offer protection up to a limit against call risk arising from faster prepayments. The main difference from PACs and TACs comes from the fact that TACs extend like sequentials if prepayments are slower than the pricing speed. Due to these characteristics, TACs appeal to investors who are more concerned about call risk and are happy to trade off extension risk offered by PACs for higher yield of TACs. Clearly TACs become more popular in a falling interest rate environment when investors are primarily concerned about average life shortening of their investments.

TAC redemption schedules are created at a single pricing speed like sequentials but unlike sequentials, the last tranche in the structure is designated as the support class. Due to the presence of the support class, a TAC structure is able to offer protection over some prepayment range (like a PAC) with the lower bound of the protection range equal to the pricing speed. However, unlike PAC a single protected range does not exist for the entire TAC structure and the last TAC class generally does not have a protected range at all. The protection band is widest for the shortest TAC (since under faster prepayment scenarios, the support bonds may still be outstanding during its amortization phase) but may not exist to support the longer maturity TAC classes. The protected range narrows as the maturity of the TAC class increases in a TAC structure.

At the pricing speed, all TAC classes pay as per schedule and the support class only amortizes after all the TACs have completely paid down. If prepayments are slower than the pricing speed then there are no cash flows available from the support bonds to be diverted to the TAC classes and consequently, like sequentials, all the TACs extend. Finally, if prepayments are faster than the pricing speed then depending upon the level of the prepayment speeds some of the shorter TACs may still pay as per the schedule and the rest contract. The longest TAC class however, is an exception. Although it contracts like others if prepayments are significantly faster than the pricing speed, it actually extends if prepayments are moderately above the pricing speed. This extension in the longest TAC occurs due to the simultaneous amortization of support bonds with the shorter maturity TACs, which reduces the outstanding collateral balance available when the longest class begins to amortize. However, significantly higher prepayments than pricing speed overwhelm the effect of reduced collateral balance causing the longest TAC to contract as well.
2. Structuring Interest Cash Flows

So far, our discussion focused on structuring principal payments of the underlying mortgage pools in a CMO deal. Another approach to structuring CMO cash flows involves dividing interest payments on the underlying collateral. It leads to the creation of some complicated bonds with interesting characteristics. e.g. Floaters and inverse floaters, structured IOs and POs and inverse IOs. Below we provide a brief introduction to the basics of structuring interest payments and leave details for a separate primer on mortgage derivatives that we will be publishing later this month.

2.1 Z-Bonds

A Z-bond is a bond that does not receive any principal payments until the other senior bonds in the structure are paid off. Thus, a Z-bond will usually have negative amortization by allowing the addition of accrued interest to its outstanding principal balance, called accretion, until all the shorter maturity tranches are paid off. The deferred interest payments on the Z-bond can be used to accelerate the amortization of the shorter maturity tranches or to service a new class of bonds known as the accretion directed bonds or (Very Accurately Defined Maturity Bonds – VADMs). The accretion cash flows from a Z-bond are independent of the prepayment speeds on the collateral until all shorter maturity tranches in the deal are paid down. The introduction of a Z-bond in a structure is therefore equivalent to curtailing extension risk in shorter duration tranches. The extent of reduction in the duration and extension risk of the shorter maturity tranches is proportional to the size of the Z-bond.

To facilitate comparison with the sequential structure discussed earlier we have created an identical structure with the final tranche replaced by a Z-bond. Note that the size of the Z-bond is set equal to the size of the fourth tranche in the original structure at the outset. The projected principal payments from the two structures at a constant speed of 175% PSA are shown in Figure 13. It may be seen that during the accretion phase of the Z-bond, the redirection of accrued interest of the Z-bond to the shorter maturity tranches shortens their WAL and payment windows and at the same time increases the size of the Z-bond.

In terms of option-adjusted characteristics, as shown in Figure 14, the introduction of a Z-bond reduces the effective duration and the option cost of the shorter maturity tranches corresponding to the bonds in the standard sequential structure shown in Figure 7. However, this improvement comes at the expense of the Z-bond, which has an increased effective duration and option cost relative to its counterpart in the standard sequential structure.
Figure 13: Comparison Between Current Pay vs. Z Structures

Source: Banc of America Securities

Figure 14: Relative Value Indicators for a Z-structure

<table>
<thead>
<tr>
<th>Bond Characteristics</th>
<th>Option Cost</th>
<th>Eff. Duration</th>
<th>Eff. Convexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9-Year Sequential</td>
<td>59</td>
<td>0.5</td>
<td>-2.3</td>
</tr>
<tr>
<td>3.8-Year Sequential</td>
<td>75</td>
<td>2.5</td>
<td>-2.4</td>
</tr>
<tr>
<td>6.9-Year Sequential</td>
<td>66</td>
<td>5.4</td>
<td>-1.7</td>
</tr>
<tr>
<td>15.5-Year Z-Bond</td>
<td>53</td>
<td>15.6</td>
<td>-1.5</td>
</tr>
<tr>
<td>Collateral</td>
<td>62</td>
<td>4.6</td>
<td>-2.0</td>
</tr>
</tbody>
</table>

Source: Banc of America Securities

2.2 VADMs

As indicated earlier, instead of accelerating the amortization on shorter maturity tranches, the Z’s accretion can also be used to service a new category of bonds called Accretion Directed Bonds or VADMs. Owing to the inherent stability in cash flows coming from Z’s accretion, VADMs are considered very stable in terms of payment window size and average life. Further, since the principal payments on VADMs come solely from the accretion on the Z-bond and do not rely on principal payments on the collateral, these bonds do not extend even under a 0% PSA environment. However, since VADMs must be amortized before the
amortization of the corresponding Z-bond begins, VADMs are exposed to call risk. Nevertheless, VADMs are somewhat protected against the call risk because the supporting Z-bond tends to be the last class that begins repaying principal if the prepayments soar. In the extreme scenario, where everybody prepays 100%, VADMs will get virtually nothing since the Z-bond would be instantaneously amortized. However, keeping the size of the supporting Z-bond small relative to all other shorter maturity bonds in the structure can mitigate the prepayment risk in VADMs.

To see how amortization works for VADMs, we have modified the Z-structure presented in Figure 13 to include two VADM tranches. Figure 15 depicts amortization of the modified structure under three different prepayment scenarios: 100% PSA, 175% PSA and 350% PSA. In all of the three cases we observe no extension in the VADMs tranches. However, as we move from 100% PSA to 175% PSA, the second VADM tranche (AD2) undergoes some shortening. As we further increase the speed to 350% PSA, both the VADM tranches (AD1 and AD2) are contracted.

Source: Banc of America Securities
The relative stability of a VADM tranche is further illustrated in Figure 16 where we compare the WAL profiles of tranche C from the standard Z-structure presented in Figure 13 with tranche C and the VADM tranche AD1 from the accretion directed Z-structure presented in Figure 15. The tranche C from the standard Z-structure is moderately stable as compared to the tranche C, which is a standard sequential tranche, from the accretion directed structure. The most stable is the AD1 tranche, which does not extend at all even when prepayment speeds drop down to zero.

Finally, option-adjusted characteristics of VADMs shown in Figure 17 confirm our intuition. VADMs have much smaller option cost and better convexities as compared to the standard sequential tranches or sequential tranches from a standard Z-structure (compare with Figure 14). VADMs are designed to protect against extension risk. They primarily appeal to investors who are sensitive to any extension in their portfolios and anticipate a rise in interest rates.

**Figure 16: WAL Comparison Between Comparable Sequential from a Z-structure and Sequential VADM from Accretion Directed Z-Structure**

![WAL Comparison Graph](image)

Source: Banc of America Securities

**Figure 17: Relative Value Indicators for an Accretion Directed Structure**

<table>
<thead>
<tr>
<th>Bond Characteristics</th>
<th>Option Cost</th>
<th>Eff. Duration</th>
<th>Eff. Convexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8-Year Sequential</td>
<td>60</td>
<td>0.5</td>
<td>-2.4</td>
</tr>
<tr>
<td>3.6-Year Sequential</td>
<td>78</td>
<td>2.5</td>
<td>-2.9</td>
</tr>
<tr>
<td>6.7-Year Sequential</td>
<td>76</td>
<td>5.6</td>
<td>-1.7</td>
</tr>
<tr>
<td>5.4-Year VADM</td>
<td>33</td>
<td>2.9</td>
<td>-1.2</td>
</tr>
<tr>
<td>10.5-Year VADM</td>
<td>41</td>
<td>5.8</td>
<td>-1.6</td>
</tr>
<tr>
<td>15.9-Year Z-Bond</td>
<td>53</td>
<td>15.3</td>
<td>-1.6</td>
</tr>
<tr>
<td>Collateral</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Coupon 5%; WAC 5.6%; WAM 356; WAL 6.8</td>
<td>62</td>
<td>4.6</td>
<td>-2.0</td>
</tr>
</tbody>
</table>

Source: Banc of America Securities
2.3 Floaters and Inverse Floaters

A fixed rate bond can be split into a pair of simultaneously amortizing floating rate bonds known as floater and an inverse floater. A floater is a CMO bond whose coupon resets periodically at a specified spread over a specified index (typically one-month LIBOR) subject to a certain cap and floor. In contrast, an inverse floater has a coupon that has an inverse linear relationship to its index, also subject to caps and floors. Figure 18 shows an example of creating a floater and an inverse floater from a fixed-rate bond.

Figure 18: Floater and Inverse Floater Structure

The structuring parameters i.e., face amounts, coupons and caps and floors of the floater and inverse floater are jointly determined such that the weighted average coupon of the pair matches the coupon on the underlying bond for all values of the index. In the above example, the ratio of face amounts of the floater and the inverse floater is 4:1. Consequently, the inverse floater has a multiplier of negative 4 in its coupon reset equation to ensure that the weighted average coupon of the bonds is equal to the coupon on the fixed-rate bond for all levels of LIBOR. As we will see subsequently, the relative size of the floater with respect to the inverse floater also determines the leverage and hence the risk of the inverse floater. Further, the cap on the floater comes from the floor on the inverse floater and vice versa. For example, the LIBOR value of 7.0%, which corresponds to the cap of 7.5% on the floater, is used to determine the cap of 28.0% on the inverse floater by multiplying it with the leverage of the inverse floater, i.e. 4. This ensures that when the floater hits its cap, the inverse floater hits its floor and vice versa. The weighted average coupon of the two bonds remains 6.0% under all cases. In general, the structuring parameters of the floaters and inverse floaters are formed based on the formulas shown in Figure 19.

By construction, an inverse floater is equivalent to a long position in the underlying fixed rate bond, partially financed through a capped floater. This implies that an inverse floater will be much more sensitive to interest rate changes as compared to the fixed rate bond due to its exposure to the additional interest rate risk from the swap.
### Figure 19: Parameters of a Floater/Inverse Floater Structure

<table>
<thead>
<tr>
<th>Structure</th>
<th>Principal</th>
<th>Coupon</th>
<th>Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed-Rate Bond</td>
<td>B</td>
<td>I</td>
<td>None</td>
</tr>
<tr>
<td>Floater</td>
<td>F</td>
<td>Index + Margin</td>
<td>$\frac{B \times i}{F}$</td>
</tr>
<tr>
<td>Inverse Floater</td>
<td>$B - F$</td>
<td>$B \times i - F \times M \arg\ in$</td>
<td>$\left(\frac{F}{B - F}\right) \times \left[\frac{B \times i}{F} - M \arg\ in\right]$</td>
</tr>
</tbody>
</table>

Source: Banc of America Securities

### 2.4 Structured IOs and POs

Any CMO bond can be divided into an IO and a PO during the structuring process. An IO receives all interest cash flows from the underlying bond and no principal payments while a PO receives all the principal payments, both scheduled and prepayments, and none of the interest. IOs are based on a notional principal balance and are therefore considered ultimate premium securities. Similarly, POs, which get none of the interest, are considered ultimate discount securities.

The investment characteristics of IOs and POs will be covered at length in a follow up primer on Trust IOs and POs. The main difference between Trust IO/POs and structured IOs/POs is that structured IOs and POs are created in a CMO deal by stripping interest and principal cash flows from either the underlying pass-through collateral or a CMO tranche while Trust IOs/POs are created by stripping interest and principal cash flows of mortgage pools.

### 2.5 Inverse IOs

An Inverse IO is an IO with a coupon similar to that of an inverse floater. i.e., the coupon has an inverse linear relationship to its index and is subject to caps and floors. The main difference between an inverse floater and an inverse IO is that the inverse floater will receive principal payments while an inverse IO will be based on a notional principal balance. An inverse IO can be created either directly from a fixed-rate bond or from an inverse floater in a number of ways. Figure 20 shows an example of an inverse IO created from a fixed-rate bond by structuring it into an inverse IO and a floater. Another example of an inverse IO, which is created by structuring an inverse floater into an inverse IO and a PO is shown in Figure 21.
Figure 20: Creation of an Inverse IO from a Fixed-rate Bond

Fixed-Rate Bond
- 6.0% Coupon
- Principal: $20m

Floater
- L+50bp cap 6.0%
- Principal: $20m

Inverse IO
- 5.5%-L floor 0%
- Notional Principal:

Source: Banc of America Securities

Figure 21: Creation of an Inverse IO from an Inverse Floater

Inverse Floater
- 28.0%-4L floor 0%
- Principal: $20m

PO
- 0% Coupon
- Principal: $20m

Inverse IO
- 28.0%-4L floor 0%
- Notional Principal:

Source: Banc of America Securities
III. BASIC CMO ANALYSIS USING BLOOMBERG

The usual market convention for pricing an agency CMO bond is to quote its I-spread, which is the difference between the yield offered by the bond and the yield offered by a similar weighted average life (WAL) Treasury security. The yield for the CMO bonds is obtained at a constant prepayment speed equal to the Bloomberg median prepayment speed. Note that the yield for a sequential bond changes with the prepayment speed, while the yield for a PAC bond remains the same for speeds within the PAC band. Therefore, the market convention calls for quoting the Bloomberg median prepayment speed in PSA along with the I-spread for sequential bonds while for PAC bonds, only the I-spread is quoted. Thus, for instance, a sequential bond may be quoted at 108/I/208 – the number 108 here refers to the I-spread while 208 refers to Bloomberg median prepayment speed in PSA for the underlying collateral.

Let’s illustrate how one can perform some basic analysis on a CMO bond using Bloomberg. FHR 3165 ND is a PAC bond that pays a coupon of 5.5% and has a WAL of 10.7 years. The underlying collateral consists of pools of 30-year passthroughs with a coupon of 5.5% and WALA of 5 months (as of September 26, 2006). This PAC bond may also be referred to as a 5.5 x 5.5 11-year PAC or as 5.5/5.5 11-year PAC; where the first number (5.5) refers to the coupon of the PAC bond, the second number (5.5) refers to the coupon of the underlying mortgage pools, and 11-year refers to the WAL of the PAC bond. On September 26, 2006 this bond was quoted at 110/ITB, which implies that the bond is priced to yield 110 bps more than the yield on a 10.7 yr treasury security as long as prepayment speeds are within the PAC band.

Figure 22 shows a snapshot of the Bloomberg description screen for this PAC bond. To perform a yield analysis on this bond, one can go to Bloomberg’s Yield Table screen by entering FHR 3165 ND<Mtge> YT<Go> (see Figure 23). The Bloomberg median prepayment speeds for the base case and for different parallel shifts of the yield curve are automatically loaded when the bond is pulled up in Bloomberg. All one has to do is to enter the quoted I-spread (110 bps for this case) and Bloomberg computes the dollar price of the bond, along with its yield in the base case and for scenarios corresponding to different parallel shifts of the yield curve (up to +/- 300 bps in increments of 100 bps). The WAL and payment window of the bond under different interest rate scenarios are also shown on the YT screen. One can also see a graphical representation of the WAL and payment window for a range of constant prepayment speeds by pulling up Bloomberg’s WALG screen (Figure 24). Notice that for a range of speeds within the PAC band, the WAL and the payment window of the PAC remain the same. Speeds higher than the upper PAC band lead to a contraction of the WAL, while speeds slower than the lower PAC band lead to an extension.

Note that this is an intermediate PAC and is therefore locked out from receiving principal payments unless the other PAC bonds in the structure with higher priority are paid off. To see how (at a constant prepayment speed) the bond will make interest and principal payments, one can use the Bloomberg’s Cash Flow Graph (CFG) screen, as shown in Figure 25.

Some market participants may also quote the bond as 110/C/ITB or 110/I.
Figure 22: Bloomberg’s Security Description Screen Snapshot (FHR 3165 ND <Mtge> DES <Go>)

Source: Bloomberg

Figure 23: Bloomberg’s Yield Table Screen Snapshot (FHR 3165 ND <Mtge> YT <Go>)

Source: Bloomberg
WAL and principal payment window remains the same for prepay speeds within the PAC band.

Faster speeds lead to contraction in both the WAL and the payment window.

Principal amortization

At 192 PSA prepayment speed, no principal will be paid for the first 105 months.
IMPORTANT INFORMATION CONCERNING U.S. TRADING STRATEGISTS

Trading desk material is NOT a research report under U.S. law and is NOT a product of a fixed income research department of Banc of America Securities LLC, Bank of America, N.A. or any of their affiliates (collectively, “BoFA”). Analysis and materials prepared by a trading desk are intended for Qualified Institutional Buyers under Rule 144A of the Securities Act of 1933 or equivalent sophisticated investors and market professionals only. Such analyses and materials are being provided to you without regard to your particular circumstances, and any decision to purchase or sell a security is made by you independently without reliance on us.

Any analysis or material that is produced by a trading desk has been prepared by a member of the trading desk who supports underwriting, sales and trading activities.

Trading desk material is provided for information purposes only and is not an offer or a solicitation for the purchase or sale of any financial instrument. Any decision to purchase or subscribe for securities in any offering must be based solely on existing public information on such security or the information in the prospectus or other offering document issued in connection with such offering, and not on this document.

Although information has been obtained from and is based on sources believed to be reliable, we do not guarantee its accuracy, and it may be incomplete or condensed. All opinions, projections and estimates constitute the judgment of the person providing the information as of the date communicated by such person and are subject to change without notice. Prices also are subject to change without notice.

With the exception of disclosure information regarding BoFA, materials prepared by its trading desk analysts are based on publicly available information. Facts and ideas in trading desk materials have not been reviewed by and may not reflect information known to professionals in other business areas of BoFA, including investment banking personnel.

Neither BoFA nor any officer or employee of BoFA accepts any liability whatsoever for any direct, indirect or consequential damages or losses arising from any use of this report or its contents.

To our U.K. clients: trading desk material has been produced by and for the primary benefit of a BoFA trading desk. As such, we do not hold out any such research (as defined by U.K. law) as being impartial in relation to the activities of this trading desk.

IMPORTANT CONFLICTS DISCLOSURES

Investors should be aware that BoFA engages or may engage in the following activities, which present conflicts of interest:

- The person distributing trading desk material may have previously provided any ideas and strategies discussed in it to BoFA’s traders, who may already have acted on them.
- BoFA does and seeks to do business with the companies referred to in trading desk materials. BoFA and its officers, directors, partners and employees, including persons involved in the preparation or issuance of this report (subject to company policy), may from time to time maintain a long or short position in, or purchase or sell a position in, hold or act as market-makers or advisors, brokers or commercial and/or investment bankers in relation to the products discussed in trading desk materials or in securities (or related securities, financial products, options, warrants, rights or derivatives), of companies mentioned in trading desk materials or be represented on the board of such companies. For securities or products recommended by a member of a trading desk in which BoFA is not a market maker, BoFA usually provides bids and offers and may act as principal in connection with transactions involving such securities or products. BoFA may engage in these transactions in a manner that is inconsistent with or contrary to any recommendations made in trading desk material.
- Members of a trading desk are compensated based on, among other things, the profitability of BoFA’s underwriting, sales and trading activity in securities or products of the relevant asset class, its fixed income department and its overall profitability.
- The person who prepares trading desk material and his or her household members are not permitted to own the securities, products or financial instruments mentioned.
- BoFA, through different trading desks or its fixed income research department, may have issued, and may in the future issue, other reports that are inconsistent with, and reach different conclusions from the information presented. Those reports reflect the different assumptions, views and analytical methods of the persons who prepared them and BoFA is under no obligation to bring them to the attention of recipients of this communication.

This report is distributed in the U.S. by Banc of America Securities LLC, member NYSE, NASD and SIPC. This report is distributed in Europe by Banc of America Securities Limited, a wholly owned subsidiary of Bank of America NA. It is a member of the London Stock Exchange and is authorized and regulated by the Financial Services Authority.