Valuation and Hedging of Inverse IOs

In a recent *Mortgage Market Comment* article ("How To Value and Hedge Inverse Floaters," November 19, 1999), we examined in some detail the characteristics of inverse floaters, with a particular emphasis on the close similarity between inverses and repo transactions. In this article, we extend the same analysis to inverse IOs. Inverse IOs are very similar to inverse floaters in the sense that they both employ inherent leverage by carving out a floater from a fixed rate and selling the floater. However, an inverse IO is a much more leveraged position in the underlying fixed rate CMO class. As a result, the inverse IO is much more sensitive to the factors that drive inverse valuations.

A Quick Introduction to Inverse IOs

An inverse IO can be understood to be the limiting case of an inverse, as both are a residual side-effect of stripping out a floater from a fixed rate tranche. The difference between the two is in the fraction of the principal that is diverted to the floater.

Inverse IOs are created in the following way:

- A fixed rate tranche of a CMO is broken up into two pieces, an inverse IO and a floater.
- The floater is backed by all of the principal of the fixed rate, with the coupon given by an index plus a margin. There is an embedded coupon cap associated with the floater which corresponds to the case where all of the interest of the underlying fixed rate bond is being diverted to the floater.
- The inverse IO is the residual of the fixed rate after splitting off the floater. It is a pure notional bond with an embedded coupon floor of zero, which implies a LIBOR cap that is struck at the underlying fixed rate less the margin on the floater.

As we discussed in the previous article, inverses and inverse IOs are very similar to mortgage repo transactions, with the corresponding floater representing the borrowed funds and the value of the inverse to be the equity, or haircut. When viewed in this way, an inverse IO is the limiting case of an inverse where all of the principal of the fixed rate is financed by the sale of the floater, achieving the maximum amount of leverage possible in the floater/inverse transaction.

As leverage is defined as the ratio of borrowed funds to equity, in the case of the inverse IO this ratio will be given by the price of floater (the amount synthetically borrowed) divided by the price of the inverse IO (the amount of equity), as the notional amounts are the same in the two cases. Therefore, the effective multiplier (or leverage) can be written:

1. EM = (Price of Floater / Price of Inverse IO)
= Leverage of Inverse IO

Many of the formulas and concepts that were developed in the previous article for inverses are immediately applicable to the current case, with the caveat that we can no longer approximate the leverage by the ratio of the floater principal to the inverse principal, as there is no inverse IO principal. We can express the duration of the inverse IO in terms of the duration of the fixed rate and floater:

2. Inverse IO Duration = Dur of Fixed +
EM × (Dur of Fixed – Dur of Floater)

Much of the intuition associated with leverage that was developed for inverses can be applied with equal validity to inverse IOs. In particular, we can approximate the yield and OAS of an inverse IO with a formula of the form:

3. Inverse IO ≈ Fixed + EM × (Fixed – Floater)

Typically, as inverse IOs have the maximum synthetic leverage possible within the floater/inverse framework, they will also have among the highest OASs, yields, and durations available in the mortgage marketplace.

Inverse IOs as Floors

Perhaps the easiest way to evaluate inverse IOs is by comparing them with LIBOR floors with the same strike. We will consider as an example GN 99-42 SC, an inverse IO stripped from 1986-87 GNMA 9s with a coupon of 8.6 – LIBOR. The corresponding floater for this bond is GN 99-42 FC, which has a coupon of L + 40 bp. Inverse IOs are structured so that the maximum interest that can be received is the underlying fixed rate less the floater margin (8.6% in our example) and the minimum is zero.

Each month, the investor receives:

Coupon = (8.6 – LIBOR) + Max(0, LIBOR – 8.6)

= 8.6 – LIBOR when 0 < LIBOR < 8.6
= 0 when LIBOR >= 8.6

on the notional balance at that time. (Note that while the inverse IO coupon cannot go above 8.6%, this corresponds to the case where LIBOR drops below zero. Therefore, while the inverse IO is short a LIBOR floor, since it is struck at zero it has no value and will be ignored.) The above cash flows are equivalent to those of a LIBOR floor struck at 8.6%. We can gain further insight into this analogy by decomposing the above cash flows into two components.

- The investor is receiving a fixed coupon less LIBOR on the notional, which is equivalent to a receiver swap.
- As the coupon on the inverse IO is restricted to never be negative, the holder of the inverse IO is also long a LIBOR cap at the fixed rate strike of the inverse IO.

We can conclude that an inverse IO is comparable to LIBOR floor of the same strike, which in turn is equivalent to a receiver swap and a cap at the fixed rate. As the average lives of plain vanilla LIBOR floors are predetermined, this analogy will be most relevant when the inverse IO cash flows are stable and prepayment risk is minimized.

Value of Inverse IOs Relative to Floors

The similarity of inverse IOs to LIBOR floors gives the investor a powerful relative value and hedging tool. As another example, we will consider FN 98-46 SC, a PAC inverse IO backed by 1998-vintage FN 6.5s, with a coupon of 8.5 – LIBOR. We will compare it with various floors of the same strike (FN 98-46 SC is offered at 8-00 as of December 3, 1999, and has a volatility-adjusted LIBOR OAS of 400 bp). We can do this either by pricing amortizing floors at various prepayment speeds, or alternatively,

LIBOR Floor Prices

Indicative LIBOR floor premiums at a strike of 8.5% for various maturities (mid-market as of Dec. 3, 1999).

	3 yr	4yr	5yr	6yr	7yr	8yr
Floor	5.64	7.35	8.96	10.50	11.96	13.33

Inverse IOs Are Attractive to Floors

FN 98-46 SC Price Pickup Versus Floors at $8-00, Under Various Speed Assumptions (CPRs in %)

CPR	6	15	20	25	30
Avg. Life	6.7	6.4	5.3	4.2	3.5
Floor Val	11-17	11-03	8-13	7-21	6-16
Pickup	**+113**	**+99**	**+45**	**-11**	**-48**

pricing floors with stated maturities at the average life of the inverse IO at various speeds. While the second approach overstates the balance for the first half of the life of the bond and understates it in the second half, often this error is small enough to allow qualitative comparison. In the following discussion, we will compare FN 98-46 SC with non-amortizing floors of various maturities, keeping in mind that we are approximating the amortizing schedule with a fixed notional and a maturity of the average life.

As FN 98-46 SC is offered at 8-00, one can see from the table at lower left that the inverse IO has value in comparison with a floor if the average life of the bond is longer than approximately 4.4 years. Another way of quantifying this is to compute the breakeven speed for the bond versus the floors market. In the table above we calculate the price advantage of the inverse IO versus the floor market at various realized lifetime speeds. If the collateral backing FN 98-46 SC prepays over the life of the bond below 24 CPR, the inverse IO will offer value relative to the floor, and if it comes in faster, it will have less value.

At the 12-month forecast speed of 7% CPR, the average life of FN 98-46 SC is 6.2 years. A floor with a 6.2-year maturity and a strike of 8.5% would be worth approximately 10-25, making the inverse IO worth approximately 75% of the comparable floor at the projected speed. While we would expect that inverse IOs would trade at a discount to the corresponding floors due to the prepayment optionality of the inverse IO, this percentage discount has been roughly constant for the inverse IO market as a whole in 1999. The inverse IO market has been cheapening in tandem with the LIBOR floor market during the backup in rates over the last year, despite the fact that the prepayment optionality for most bonds is greatly reduced at current rate levels. As such, we believe that inverse IOs offer value relative to the floor market at current levels.

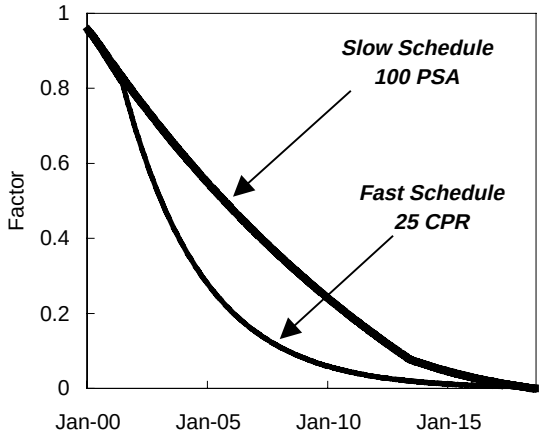
Hedging Inverse IOs

Floors can be used as a relative value benchmark, or as a way to capture that value when viewed as a hedge. Simply, an investor could sell floors of the same strike, matching some prescribed amortization schedule, and pocket the difference in premium between the inverse IO and the floor. While this would hedge the cash flows at a particular prepayment speed, the investor would still be exposed to average life variability in the inverse IO.

As an alternative, we will consider a variant on the above approach which would hedge an investor from average life variation by entering into cancelable swaps.

- As the inverse IO coupon is equivalent to a receiver swap, the investor would enter into a payer swap (paying the fixed strike of the inverse IO and receiving LIBOR on a monthly basis) in order to hedge the coupon.
- The notional of the swap is variable, and is determined in the following way: Two prepayment speeds are chosen, an upper and a lower speed, forming a range in which the investor believes the collateral will prepay. These two prepay speeds will imply two amortization schedules and two balances at each point in time.
- The baseline notional on the swap will follow the lower speed band, and the investor has the right to cancel some portion of the swap each month, as long as the balance of the swap remains within the upper and lower bands implied by the two prepayments speeds. This has the effect of allowing the investor to match the balance of the swap with the balance on the inverse IO for a reasonable range of prepayment behavior.
- Embedded in the inverse are caps on LIBOR at the strike of the inverse (8.5% in the case of FN 98-46 SC). The investor could sell these caps at some targeted speed, or wrap the caps into the cancelable swap to form a cancelable floor.

Hedging FN 98-46 SC With Cancelable Swaps
Amortization Schedules at 100 PSA and 25% CPR for FN 98-46 SC



The package would be structured to take out a premium while matching cash flows under a variety of prepayment scenarios. In the case of FN 98-46 SC, we could conservatively choose 100 PSA and 25% CPR as the upper and lower bands, respectively. To put these speeds in perspective, during the 1998 refinancing wave the peak one-month speed on any vintage FN 6.5 was 25% CPR. By choosing this speed as our upper band, we are hedging against a *lifetime* speed of 25% CPR, not just a peak speed. Further, we project that even in a sell-off of more than 300 bp, the long-term speeds on 1998 vintage 6.5s will not drop below 100 PSA. This projection is based at least in part on the lack of borrower self-selection in 1998 vintage discounts and the corresponding high turnover rates.

In the graph above, we plot the amortization schedule at these two speeds for FN 98-46 SC. Each month, the investor has the right to cancel some amount of the swap, as long as the balance of the

Mechanics of Hedging FN 98-46 SC With Cancelable Swaps
Hedging an Inverse IO With Cancelable Swaps (LIBOR refers to one-month LIBOR).

Transaction	Receive	Pay
Buy FN 98-46 SC	8.5%	LIBOR (capped at 8.5%)
Enter into cancelable payer swap. Investor has right to cancel swap as long as balance remains in bands. Investor could choose 100 PSA and 25% CPR as upper and lower bands on speeds.	LIBOR	8.5%
Sell caps on LIBOR struck at 8.5%	premium	Max(LIBOR – 8.5%, 0)

swap stays within the area between the upper and lower balances formed by the two speeds. This allows the investor to adjust the notional on the swap depending on the realized speeds on the underlying collateral. Further, the investor could sell the embedded caps, either by choosing a specific amortization schedule or wrapping them into the cancelable swap to form a cancelable floor.

Clearly, the cost associated with gaining the right to cancel the swap will be a function of how much area is between the two amortization curves. This gives a clear visualization to the meaning of negative convexity: For bonds with a great deal of potential average life variation, the optionality that an investor must buy back will increase, leaving less extra income available for the investor. In the table at the bottom of the previous page, we outline the structure of the hedge.

It is important to note that this structure has positive convexity due to the fact that each month the investor can cancel any portion of the swap as long as the notional remains between the prescribed balances. It may be economical to have the swap balance be more than, or less than the balance of the inverse IO depending on rates. This extra optionality can be monetized by the investor in various ways.

Prepayment Sensitivity of Inverse IOs

While both inverses and inverse IOs are leveraged purchases of cash flows through the sale of a floater, they can differ significantly in their sensitivity to prepayment speeds. As the inverse IO is often much like a leveraged position in a premium security, prepayments in the form of faster relocations and more efficient refinancings will generally be a negative for the bond. For an inverse, however, the response to faster speeds will be much more muted, and can in certain cases be positive. In order to see this, we can decompose the inverse into an inverse-IO/PO combination. While the inverse IO component will react like a leveraged premium position, the PO component will react more like an unleveraged discount position. In the inverse-IO/PO combination, these two responses will compete with each other to produce a more muted response to prepayment speeds than either of the two components. As an example, we will compare the response of an inverse and an inverse IO to three different prepayment shocks to show the differing nature of the leverage.

The inverse we consider is FN 99-32 SD, a type-II PAC inverse with the formula $2.4 \times (8.05 - \text{LIBOR})$ backed by FN 6s. We compare this with FN 98-46 SC, the inverse IO from the previous section. Both are backed by discount collateral, have somewhat similar strikes on the coupon, and have degrees of PAC structure. However, in the table that follows we can see several differences between the two bonds. First, the inherent leverage of FN 98-46 SC is much greater than that of FN 99-32 SD, reflected in the wide difference in OAS between the two bonds. Second, the two bonds have very different responses to prepayment shocks. While the OAS of FN 98-46 SC is reduced by a 10% increase in refinancings, a 10% increase in relocations, and a 25 bp shift in the cusp for refinancings, these three shocks actually benefit FN 99-32 SD. Of particular note is the strong positive sensitivity of FN 99-32 SD to an increase in relocations.

While inverses and inverse IOs both provide the investor with the ability to leverage cash flows, inverse IOs typically employ much higher levels of leverage through the sale of the floater. Investors should keep in mind that inverses can often have significant PO-like behavior, particularly for deep discount dollar prices, while inverse IOs are often equivalent to leveraged premium positions. Particular care must be taken in understanding the nature of the sensitivity of each individual bond.

Inverses and Inverse IOs Can Have Very Different Response to Prepayment Speeds

The OAS Sensitivity of FN 98-46 SC and FN 99-32 SD to Various Prepayment Shocks.

Bond	Price	LIBOR OAS (bp)	Refi +10% (bp)	Relo +10% (bp)	Cusp +25 bp (bp)
FN 98-46 SC	8-00	400	-25	-24	-44
FN 99-32 SD	88-11	74	+1	+135	+30

Opportunities in Inverse IOs

With the traditional investor base for mortgage derivatives less active currently, investors can take advantage of the opportunity to profit by leveraging cheap cash flows through the inverse IO market. A valuable way of determining the value of these cash flows is by comparing them with the floor market, particularly in cases where the average life variation is minimized. As a direct illustration of extracting the value of an inverse IO, an investor could enter into a cancelable swap designed to hedge out the

LIBOR exposure while allowing the investor the ability to adjust the notional depending on the rate of paydowns. When viewed in this way, the capital markets provide both a relative value benchmark for the inverse IO market and a way to extract that value.