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Valuation of Inverse IOs and Other MBS Derivatives

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I. Fear of Unmodeled Prepayment Risks

Thanks to the recent refinancing wave, MBS derivatives that suffer from prepayments have cheapened. For example, the OAS of Fannie Mae Trust 240 IO has widened from 24bp on April 14, 1998 to 413bp on August 14, 1998. Because the OAS has, by definition, been adjusted for rate risks, and is calculated with a prepayment model that has been revised to reflect the increased efficiency in refinancing activities,[1] it seems that investors fear yet higher levels of refinancing efficiency and demand a commensurate risk premium.

Whether or not the fear is justified, only time will tell. Meanwhile, investors not averse to prepayment risks can find many cheap securities that could be rewarding should future refinancing efficiency turn out to be milder than that priced in the current market. Some of these securities have OASs in the thousands for the simple reason that their prepayment risks are leveraged manifold.

One example of these structured securities is an inverse IO, a security that receives no principal and that has a coupon that is inversely proportional to LIBOR, with a cap and a floor. Effectively, the holder invests in a fixed-coupon bond, finances part of it at LIBOR, and buys a cap on the financing rate. The cap is on the prepayable balance and is therefore subject to prepayment risk. The leveraging multiplies whatever prepayment risks that come with the fixed-coupon bond.

Another example is a support bond that accompanies a PAC in a CMO. It can be regarded as a fixed-rate tranche financed by selling the PAC. Since the PAC has little prepayment risk, that in the support bond is leveraged up.

In order to assess the relative value of such securities, we need a method to quantify the prepayment risk in each, and at the same time, extract the risk premiums from the market.

[1] See “Update to Salomon Smith Barney Prepayment Model,” *Bond Market Roundup: Strategy*, Salomon Smith Barney, May 29, 1998.

II. The Breakeven Prepayment Model and the Implied Prepayment Model

Traders and investors have long been aware of the need to account for unmodeled prepayment risks in the valuation of structured securities.

One method is to apply a multiplier to the prepayment model so as to cause a PO/IO pair to have equal OAS at the pair's market prices. The breakeven multiplier and breakeven OAS thus obtained will represent the information as to the market's price of prepayment risks. Together, they are used to price any CMO whose collateral is similar to that for the strip pair.[2]

One drawback to the breakeven method is that CMOs without any prepayment risk would be priced at the breakeven OAS even when some such bonds are actively trading at a different OAS. Examples are wide-banded PACs and floaters with high caps and low floors. An attempt to circumvent this difficulty would be to replace the breakeven OAS with the OAS of agency debentures and keep the breakeven multiplier. This, however, would somewhat misprice the strips and could severely misprice some structured bonds. For example suppose the breakeven OAS is 50bp and the breakeven multiplier is 120%. Pricing a PAC with these parameters has the same effect as pricing it at an OAS of 50bp at the 100% model if the PAC band is unlikely to be broken. If the PAC is trading at 40bp OAS at 100% prepayment model we would be off by 10bp. If the PAC/support ratio is 4:1, then the support class would be mispriced by roughly 40bp OAS.

An extension to the breakeven method is to replace the PO/IO pair with a large, representative set of MBS pass-throughs and strips. Several prepayment model parameters, along with an OAS, are adjusted so as to minimize the discrepancy between the resulting model prices of the selected benchmarks and their respective market prices. The implied prepayment model and the implied OAS are then used to price CMOs. One disadvantage in the context of pricing specific CMOs is that we do not fully use the market price information of the specific PO/IO pair whose collateral most resembles that of the CMO, even when such is available. Another, as in the case of the breakeven method, is that the implied OAS may not be suitable for bonds free of prepayment risks.

These considerations lead us to the following scheme: The OAS is fixed at a level obtained from prepayment risk–free bonds, for example the agency OAS or some fixed level below the LIBOR swap spread. Then, two selected prepayment model parameters are adjusted so as to produce exactly the market prices of a specific PO/IO pair.

Two prepayment model parameters are needed because these are two prices, PO and IO, to match. An example of a pair of prepayment parameters that can be used is the refinancing speed multiplier and housing turn-over speed multiplier.[3]

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[2] *Understanding PAC IOs,* Salomon Smith Barney , October 1992.

[3] For the conceptual understanding of the discussion the reader can keep this pair in mind although the Salomon Smith Barney implementation uses a different pair.

The implied prepayment model, along with the OAS, are used to price only CMOs whose collateral resembles that of this reference strip pair.

III. Prices of Prepayment Risk and the Implied Prepayment Model

Another method to account for prepayment risks is to first define prepayment risks as the price sensitivities to two model parameters when the latter change slightly from zero. A prepayment risk–free bond would be priced at the OAS of agency debentures. Others are subject to additional price concessions that are multiples of their respective prepayment risks. The two multipliers are chosen so that the reference PO/IO pair, after the discounts, would be priced exactly at market levels. The multipliers thus obtained are the prices of prepayment risks associated with the PO/IO pair.

One drawback of this method is that, unlike the implied prepayment method, it could produce negative prices. Actually, the implied prepayment parameters can be regarded as a refinement of the prices of prepayment risks just described, and can be called prices of prepayment risk for that reason.[4] Hereafter, we will use the two terms interchangeably.

[4] To see this, let f(security,p1,p2) denote the price at the nominal OAS of a security with the prepayment parameters p1 and p2 whose nominal values are zero. The prices of risk r1 and r2 are defined such that

$$\text{market price of PO} = f(PO,0,0) + r1 * \partial f(PO,0,0) / \partial p1 + r2 * \partial f(PO,0,0) / \partial p2$$
$$\text{market price of IO} = f(IO,0,0) + r1 * \partial f(IO,0,0) / \partial p1 + r2 * \partial f(IO,0,0) / \partial p2$$

The expressions on the right hand sides are the first order terms of the Taylor expansion. Therefore, ignoring second order error, we have

$$\text{market price of PO} = f(PO,r1,r2)$$
$$\text{market price of IO} = f(IO,r1,r2)$$

This is none other than the definition of the implied prepayment.

IV. Performance of Three Methods in the Prediction of MBS Strip Prices

In addition to arriving at a fair price today, the implied prepayment method can be used to give scenario horizon prices in a rate-of-return analysis. The implied prepayment parameters (a.k.a. prices of prepayment risks) will be held constant, along with the nominal OAS (plus any additional OAS as the trade price would determine) at the horizon.

Figure 1 compares the historical performance of price prediction using this method with the OAS method and the breakeven method. The Root-Mean-Square (RMS) of price prediction errors are listed for five PO/IO Trusts and their respective collaterals. The OAS method outperforms in the case of collateral. The implied prepayment method and the breakeven method have comparable errors, significantly smaller in RMS than the OAS method in the case of strips.

Figure 1. RMS Error (per 100 face amount) in Predicting Monthly Price Movements

Security	Method	TR.240 Since Feb94	TR.252 Feb94	TR.237 Dec93	TR.270 Aug95	TR.268 Jul95
PO	OAS	0.74	0.91	1.05	0.71	0.74
IO	OAS	0.86	0.93	1.09	0.68	0.68
COL	OAS	0.36	0.37	0.46	0.30	0.30
PO	Breakeven Parameters	0.65	0.70	0.87	0.77	0.71
IO	Breakeven Parameters	0.78	0.76	0.91	0.76	0.64
COL	Breakeven Parameters	0.39	0.47	0.63	0.29	0.27
PO	Implied Prepayment Model	0.65	0.70	0.90	0.78	0.73
IO	Implied Prepayment Model	0.79	0.73	0.81	0.75	0.64
COL	Implied Prepayment Model	0.37	0.45	0.56	0.31	0.30

Source: Smith Barney Inc./Salomon Brothers Inc.

To give some intuition, we use the implied prepayment method to predict the prices of a PO/IO pair and then derive their OAS (the usual one relative to the nominal prepayment model) and the breakeven parameters. These are listed in Figure 2. The method thus predicts an OAS widening of 326bp for the IO in a 50bp rally, and a tightening of 119bp in a 50bp selloff.

Figure 2. OAS of FHL.PC.177 PO and IO Projected with Constant Prices of Prepayment Risks, 8 Jul 98

Scenario	-50bp	-25bp	0bp	+25bp	+50bp
PO OAS	-112bp	-93bp	-79bp	-71bp	-67bp
IO OAS	777	572	451	379	332
BE Multiplier	129.2%	127.3%	125.9%	124.8%	124.0%
BE OAS	35bp	38bp	38bp	38bp	38bp

Source: Smith Barney Inc./Salomon Brothers Inc.

Assured that the implied prepayment method performs at least as well as the breakeven method in the case of strips, we are ready to apply it to CMO derivatives.

VII. Valuation of CMO Derivatives

As illustration, we apply the implied prepayment method to the inverse IO, GNMA98.2-SW, which has a coupon of (8.5 - LIBOR1). The collateral is Ginnie Mae 7.0 with WAM=26.5 years. There is no Ginnie Mae Trust that can serve as the reference strips for this bond. As a conservative surrogate, we use the Trust FHL.PC.177 PO/IO pair whose collateral is a Freddie Mac Gold 7.0 with WAM= 27 years. From market prices for the Trust PO, we find the prices of prepayment risks using LIBOR for discounting so that a floater with uncapped coupon equal to one-month LIBOR will be priced at par. With this implied model, the prepayment risk-adjusted price of the inverse IO can be obtained. This is the fair price. If a trade occurs at a price other than the fair price, we can add a spread to the discounting rates so as to match the trade price. This spread is the prepayment risk–adjusted OAS and measures the cheapness of the bond after prepayment risk.

Because of the difference between CMO and LIBOR day counting, the floater OAS relative to Treasury would be approximately 10bp below the swap spread. Thus, we price prepayment risk-free bonds at approximately 10bp below the swap spread. A prepayment risk-adjusted OAS of 30bp for a prepayment risky CMO would, for example, be approximately 20bp over the swap spreads with the implied prepayment model. If the swap spread is 40bp then the OAS of this CMO relative to Treasury would be 60bp with the implied prepayment model.

We use a price of 16 for GNMA98.2-SW on August 18, 1998. With the implied prepayment model, this corresponds to a prepayment risk–adjusted OAS of -43bp. Thus, the bond is richer than would be indicated by the market prices of prepayment risks, except for the fact that the reference strip pair from Trust FHL.PC.177 is a conservative prepayment reference, since Ginnie Mae pass-throughs in general prepay more slowly than conventional pass-throughs of the same coupon and weighted average life.

To get another indication of the value of the bond, we can combine it with some PO, interest-rate, and volatility benchmarks to form a portfolio that replicates the pass-through under a set of representative scenarios. Specifically, we use the prepayment risk–adjusted OAS and the implied model to project the prices of the CMO, the PO, IO, and the collateral of FHL.PC.177 at the one-month horizon under various scenarios. The scenarios and the corresponding future values are listed in Figure 3. The scenario designated nc stands for no change in rates, volatility, or prices of prepayment risks. The scenario YC-- has ten-year rate shifted down 50bp and other rates and the volatilities shifted according to projections from empirical covariance, given the shift in the ten-year rate; the prices of prepayment risks are kept fixed in this scenario. The scenarios YC-, YC+, and YC++ are similarly obtained from the ten-year rate shift of -25bp, +25bp, and +50bp, respectively. The scenario 2TR+ means a shift of the curve by 10bp at the two-year point and 0bp at the five-year point (linear interpolation and constant extrapolation elsewhere). The scenario vc2+ and vs1+ have change of volatility of 1% for the two-year cap and the one-year into ten-year swaption, respectively. The scenario designated PPM1+1 stands for an increase of 1 point in the first price of prepayment risk. The meaning of the other scenarios should now be obvious. The letters in the benchmark names are self explanatory. Following the letters is a date of maturity or expiration, and then the coupon or strike, as the case may be. The interest-rate benchmarks are self-financed.

Figure 3. Future Values and ROR of Collateral and Replicating Portfolio Using Inverse IO, PO Interest Rate Benchmarks and Cash

Trade Date August 18, 1998

Yield Curve	**3m**	**6m**	**1Y**	**2**	**3**	**5**	**10**	**30**
	5.08	**5.19**	**5.25**	**5.34**	**5.34**	**5.34**	**5.41**	**5.56**

Scenario Future Value	**Face**	**BASE**	**nc**	**YC--**	**YC-**	**YC+**	**YC++**	**2TR+**	**5TR+**	**30TR+**	**2LB+**	**5LB+**	**vc2+**	**vc5+**	**vs1+**	**vs5+**	**PPM1+1**	**PPM2+1**
			1 mon	1 mon	1 mon	1 mon	1 mon	1 mon	1 mon	1 mon	1 mon	1 mon	1 mon	1 mon	1 mon	1 mon	1 mon	1 mon
Portfolio I Components																		
Collateral	370.41	378.09	380.2	382.56	381.82	377.43	373.92	379.89	379.85	380.12	379.46	379.71	380.18	379.94	380.03	379.84	380.16	380.21
Portfolio II Components: (Benchmarks Financed, Treasuries at 5.00, Others at 5.59)																		
GNMA98.2-2-SW	100.00	16.04	16.26	16.28	16.50	15.63	14.76	16.13	16.03	16.29	15.94	15.91	16.25	16.27	16.21	15.87	16.20	16.25
FHL.PC.177-1	47.15	37.57	37.69	41.51	39.71	35.98	34.47	37.68	37.66	37.63	37.62	37.64	37.69	37.77	37.70	37.69	37.71	37.72
tre20000815_5.339	175.86	0.00	0.07	1.49	0.78	-0.63	-1.33	-0.24	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
tre20030815_5.343	-154.83	0.00	-0.06	-2.76	-1.40	1.27	2.59	-0.04	0.59	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06
tre20080815_5.408	-15.17	0.00	-0.01	-0.60	-0.30	0.28	0.55	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
tre20280815_5.556	4.11	0.00	0.00	0.28	0.14	-0.13	-0.25	0.00	0.00	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
edf20000918_5.765	692.54	0.00	0.00	0.94	0.47	-0.47	-0.93	-0.02	-0.14	0.00	-0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
edf20030915_5.980	235.86	0.00	0.00	0.43	0.21	-0.21	-0.43	0.00	0.01	0.00	0.00	-0.06	0.00	0.00	0.00	0.00	0.00	0.00
cap20000818_5.750	70.96	0.00	-0.04	-0.19	-0.14	0.15	0.40	0.01	-0.04	-0.04	0.01	-0.04	-0.02	-0.04	-0.04	-0.04	-0.04	-0.04
cap20030818_6.000	-288.87	0.00	0.28	2.29	1.40	-1.17	-3.07	0.42	-0.35	0.28	-0.03	0.13	0.26	-0.07	0.29	0.29	0.28	0.28
swn19990818_6.107	-69.19	0.00	0.05	-2.41	-1.07	0.64	1.11	0.02	0.06	0.07	0.14	0.20	0.05	0.05	-0.06	0.05	0.05	0.05
swn20030818_6.306	9.51	0.00	0.00	0.28	0.13	-0.08	-0.14	0.00	0.02	-0.01	0.00	-0.03	0.00	0.00	0.00	0.02	0.00	0.00
cal19981018_101.913	69.81	0.00	-0.10	1.19	0.24	-0.16	-0.16	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.09	-0.10	-0.10	-0.10
cal19981018_99.980	-82.43	0.00	0.20	-2.42	-0.89	0.62	0.69	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.16	0.20	0.20	0.20
cal19981018_98.091	11.28	0.00	-0.01	0.41	0.19	-0.16	-0.22	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Cash(at 5.59)	324.48	324.48	325.96	325.96	325.96	325.96	325.96	325.96	325.96	325.96	325.96	325.96	325.96	325.96	325.96	325.96	325.96	325.96
Portfolio I		378.09	380.20	382.56	381.82	377.43	373.92	379.89	379.85	380.12	379.46	379.71	380.18	379.94	380.03	379.84	380.16	380.21
Portfolio II		378.09	380.30	382.66	381.92	377.53	374.02	379.99	379.95	380.21	379.56	379.81	380.28	380.04	380.13	379.94	380.26	380.31
Advantage of II over I		0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Scenario Annualized ROR:																		
Portfolio I			6.87	14.8	12.31	-2.12	-13.06	5.86	5.72	6.6	4.44	5.27	6.82	6.01	6.32	5.69	6.74	6.91
Portfolio II			7.19	15.14	12.64	-1.81	-12.76	6.19	6.04	6.92	4.76	5.59	7.14	6.33	6.64	6.02	7.06	7.24
Advantage II over I			0.32	0.33	0.33	0.31	0.30	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32

Source: Smith Barney Inc./Salomon Brothers Inc.

Figure 3 shows that using the CMO, some PO, some interest-rate benchmarks, some volatility instruments and cash we can replicate the Trust collateral. We can actually pick up about one tick in each of the scenarios. Annualized, this translates to a rate-of-return advantage of about 30bp. This appears to contradict the negative risk–adjusted OAS of -43bp. One reason for the apparent discrepancy is that we use the 100% Salomon Smith Barney Prepayment Model in the one-month projection of cash flow and balances of the mortgage bonds, a less pessimistic view of next month’s prepayments than that of the implied model. There is no contradiction in using the best prepayment model for the projection of the cash flows on the one hand, and using available information on the market of prepayment risk premiums for the projection of *prices* on the other. This is akin to using the forward curve in pricing even though we may believe a no-change scenario is most likely.
Note that in calculating the excess return of the replicating portfolio we do not necessarily advocate the replication. An investor may buy the inverse IO to take a position in future prepayment speed, in interest rates, in volatilities, or any combination. In that case, he would exclude the PO and/or some benchmarks in the replicating portfolio, or he might not hedge at all. The excess return in the replicating portfolio in Figure 3, however, shows that he is paying a fair price for the inverse IO, however it is used.

There are limitations to the method. The first limitation is the assumption that the reference strips are a reasonable proxy for the collateral of the CMO in question. Also, we use two prepayment risk parameters which may fail to capture the risks that might affect particular classes of CMOs. For example, the market prices of risk derived from PO and IO may fail to adequately reflect investors' fear of very near term prepayments; the market often demands a higher risk premium for very short structured IOs. As for the excess return in the replicating portfolio, a hedge or replication constructed with the 15 scenarios listed in Figure 3 may not hold up in other scenarios; for example, there may be significant convexity effects when the yield curve shifts 50bp *and* the prices of prepayment risk also changes.

Subject to these cautions, we have a method that realistically compares the relative value of CMOs regardless of their structure and leverage. The prepayment risk-adjusted OAS and the excess ROR of the replicating portfolio provide useful measures.

ADDITIONAL INFORMATION AVAILABLE UPON REQUEST

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