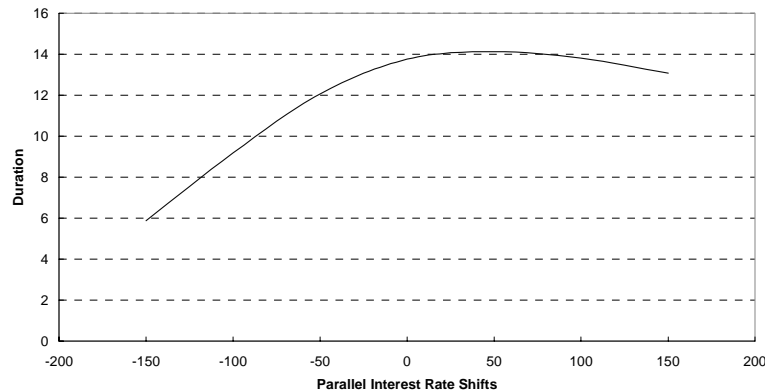Samuel Choi
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PO Convexity Drift

Effective duration and effective convexity are the two primary measures of risk for mortgage-backed securities. However, they have their limitations as complete risk measures.[6] For example, in Figure 2, we look at the durations of FNMA 93-157 E, a TAC-PO, at different interest-rate levels. On the y-axis is duration and on the x-axis different rate movements. On this particular date, the effective duration of this bond is 13.76, and the effective convexity is 0.27. Because the convexity of the PO is near zero, a traditional fixed-income investor may be misled into thinking that the duration of this bond is relatively stable. In fact, as Figure 2 shows, the duration shortens quite dramatically if rates move lower. This phenomenon is known as **duration drift.** Effective convexity is a locally linear approximation of duration drift, but as Figure 2 shows, often duration drifts in a nonlinear fashion.

Figure 2. Duration Drift Graph of Fannie Mae 93-157 E, 11 Dec 97

Source: Smith Barney Inc/Salomon Brothers Inc.

Convexity Also Drifts. A bond that looks attractively convex at current rate levels may not look so enticing at other rate levels. Take a look at Fannie Mae 93-146 E, a PAC-PO, and Fannie Mae 93-146 G, a TAC-PO off the same deal. The collateral backing the deal is Fannie Mae Trust 221 and Trust 218 (1993-originated Fannie Mae 30 year 7.5%). As Figure 3 shows, they both have the same OAS — 42bp. However, their durations and convexities are quite different. The E class has a much lower duration and convexity than the G class.

When the OAS of two bonds are equivalent, looking at convexity drift may help the investor choose the bond with the more attractive return profile.

Figure 3. Valuation Summary of Fannie Mae 93-146; Classes E and G, 11 Dec 97

	Coll	WAC	WAM	Price	OAS	Eff. Dur.	Eff. Cnvx.
FN93.146 E	FN30	7.989%	24.08yrs	$62.088	42bp	8.61	1.80
FN93.146 G	FN30	7.989	24.08	70.259	42	27.47	12.62

Source: Smith Barney Inc/Salomon Brothers Inc.

However, if we look at the convexity of these bonds at other rate levels, the E class shows a much more stable and attractive convexity profile (see Figure 4).

Figure 4. Effective Convexity Profiles, 11 Dec 97

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[6] For similar discussions of this topic, please refer to Ronald Kahn's paper "Fixed Income Risk Modeling for the '90's" in the Fall 1996 *Journal of Portfolio Management* or Samuel Choi's paper "Effective Durations for MBS: Recipes for Improvement" in the March, 1996 *Journal of Fixed Income*.

Effective Convexity	-150	-100	-50	0	50	100	150
FN93.146 E	-1.408	11.044	10.401	1.796	0.638	0.803	0.275
FN93.146 G	-19.238	-20.218	-1.859	12.617	11.611	9.443	7.117

Note: Run with 1000 path. Source: Smith Barney Inc/Salomon Brothers Inc.

OAS models assume that hedging is continuous and frictionless, and that the transaction costs are negligible. In fact, transaction costs can be high because of severe convexity drift.

One way to evaluate the volatile convexity profile of class G versus class E is in terms of **dynamic hedging costs**. If interest rates move downward, the convexity of class G goes from being significantly positive to significantly negative. The investor must now purchase options to hedge out the negative convexity of the position. On the flip-side, in the same situation, the convexity of class E goes from being slightly positive to significantly positive. The investor, in this situation, can now actually sell some options and add incremental income because of the transaction.

Figure 5 presents another way to see that the dynamic hedging costs may be less for the E class than the G class. Figure 5 shows the projected durations of two portfolios at different rate levels. Portfolio number 1 is a duration-neutral and prepayment-neutral combination of Fannie Mae 93-146 E, Fannie Mae Trust 221 7.5% IO, and a short position in Treasuries. The IO could be viewed as a **proxy for a mortgage servicer's liabilities**. Portfolio number 2 is the G class combined with Fannie Mae Trust 221 7.5% IO and short Treasuries, also duration-neutral and prepayment-neutral. As the figure shows, the duration of portfolio number 2 shifts quite radically when rates move up or down.[7] In addition, since the convexity of the G class becomes negative as rates move down, given the current structure of prices in the PO market, the OAS would probably widen on the G class shortening the duration of the bond even more. For a **mortgage servicer** who would be purchasing the PO as a hedge for a downward move in interest rates, **we believe that it could make more sense to purchase the E class than the G class, since the dynamic hedging costs could be significantly less for the E class.**

Figure 5. The Effect of Convexity Drift on Portfolio Durations, 12 Dec 97

	Coupon	Prep Dur	Vol Dur	Mkt Amt ($M))	Effective Durations						
					-150	-100	-50	0	50	100	150
FN.TR.221	7.500%	0.58	1.69	24,420	-55.425	-60.485	-45.619	-29.054	-17.298	-9.984	-5.553
FN93.146 E	0.000	-0.12	-0.20	117,217	16.164	16.201	11.905	8.585	8.516	8.230	7.956
10yr. Tsy.	6.125	0.00	0.00	(41,637)	7.329	7.263	7.197	7.130	7.064	6.996	6.929
Portfolio:		**0.00**	**0.13**	**100,000**	**2.36**	**1.15**	**-0.18**	**0.00**	**2.82**	**4.30**	**5.08**

	Coupon	Prep Dur	Vol Dur	Mkt Amt ($M)	Effective Durations						
					-150	-100	-50	0	50	100	150
FN.TR.221	7.500%	0.58	1.69	24,420	-55.425	-60.485	-45.619	-29.054	-17.298	-9.984	-5.553
FN93.146 G	0.000	-0.39	-0.40	36,317	5.971	16.075	25.158	27.506	25.107	22.528	20.551
10yr. Tsy.	6.125	0.00	0.00	(40,591)	7.329	7.263	7.197	7.130	7.064	6.996	6.929
Portfolio:		**0.00**	**0.44**	**20,146**	**-71.18**	**-58.97**	**-24.44**	**0.00**	**10.06**	**14.41**	**16.36**

Source: Smith Barney Inc/Salomon Brothers Inc.

For investors who buy these POs outright (not in combination with IOs or as a hedge for mortgage servicing portfolios), exposure to prepayment projection errors should be of concern. These investors should be aware that Fannie Mae 93-146 G is much more dependent on the prepayment projection being correct in order to attain a positive OAS. Figure 6 shows the OASs of these bonds at different multiples of our prepayment model. If actual prepayments are even slightly slower than our projections (even by 0.6 CPR), then the OAS of 93-146 G is negative. In contrast, 93-146 E has much more of a cushion for prepayments before the OAS becomes negative

[7] Due to the differences in the sizes of the two hedged portfolios, it could be argued that the duration drift of the portfolio hedged with the G bond is overstated relative to that of the portfolio hedged with the E tranche. However, even accounting for the differences in portfolio size, the E bond provides a more stable hedge. As an approximation, one could divide the portfolio durations of portfolio #2 by the ratio of the sizes of the two portfolios (approximately 5.0).

(the OAS is zero at 75% of our prepayment model — about a 3 CPR cushion).

Figure 6. OAS Sensitivities to the Prepayment Model, 11 Dec 97

OAS	SB Model								
	80%	85%	90%	95%	100%	105%	110%	115%	120%
FN93.146 E	11	20	28	35	42	50	59	67	75
FN93.146 G	-127	-89	-48	-6	42	92	145	202	265

Source: Smith Barney Inc/Salomon Brothers Inc.

According to risk-neutral pricing theory, because the OASs on these two bonds are equal, neither bond is superior to the other. **However, in a world where transaction costs involved in rebalancing portfolios can be significant, and in which prepayment projection error is recognized, investors may prefer the E class over the G class.** In other words, when choosing between two bonds, OAS analysis is the most important gauge of risk and value, but there are other factors that OAS analysis fails to address (such as transaction costs and prepayment projection error). In cases in which these factors could be significant, it may be worthwhile to look beyond OAS, duration, and convexity.