Stepping Beyond Duration Matching

Many life insurers follow a duration-matching investment strategy, but is it the best approach?

Many life insurers follow a duration-matched investment strategy, whose main objective is to minimize interest-rate risk. While the approach is understood and accepted by investment professionals, regulators, and rating agencies, it has some weaknesses as well as benefits. There is a new approach, however, that can provide insight into the risk/reward trade-offs of duration matching.

The new method, which uses stochastic modeling, considers the company's policyholder obligations as well as regulatory and tax issues, and reserving and capital constraints. Analyzing those results within an efficient frontier framework, given a company's financial objectives and risk tolerance, can help identify an optimal investment strategy.

Let's use a hypothetical in-force block of deferred annuities to illustrate how duration matching does and doesn't work and how the new approach may identify additional investment opportunities. All references to "our insurer" are based on this hypothetical case example.

Our hypothetical insurer's block of business has initial statutory reserves of approximately $848 million and a target surplus of $42 million. The company resets policyholder credited rates annually to the portfolio yield, less a spread. The duration of both the assets and liabilities is 3.4. Figure 1 illustrates the composition of the asset portfolio.

Duration Matching Pros and Cons

Like many life insurers, our hypothetical company uses a duration-matched strategy to control or minimize interest-rate risk. Under such a strategy, companies set the liability duration as the target duration for the asset portfolio and establish a range within which the portfolio duration must be maintained. This provides the portfolio manager with some latitude to add value while limiting the insurance company's exposure to interest-rate risk.

Benefits of a duration-matched strategy include:

- Reasonably effective at controlling interest-rate risk;
- Easy to implement and monitor;
- Broadly accepted by the actuarial, investment, regulatory, and rating agency communities.

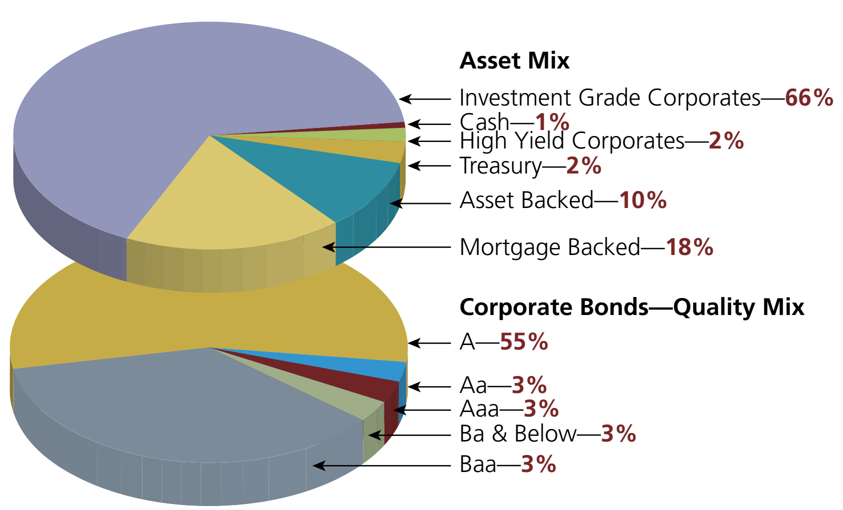
Limitations are:

- Only effective for small changes in interest rates;
- Doesn't reflect the risk associated with non-parallel yield curve shifts;
- Sensitive to actuarial assumptions and the investment strategy backing the liabilities;
- Fails to consider management's financial objectives and risk tolerance.

Handling Convexity

The first limitation—that duration is effective only for small changes in interest rates—can be addressed by considering convexity. Convexity measures the rate of change in price caused by a change in interest rates. Positive convexity implies that prices rise at an increasing rate as

FIGURE 1



	Book Value	Market Value	Accrued Interest	Effective Duration	Average Coupon	Book Yield	Market Yield
Cash	11.6	11.6	0.0	0.0	1.50%	1.50%	1.50%
Treasury	26.1	26.0	0.5	4.2	4.66%	4.32%	4.47%
Asset Backed	91.6	94.2	0.5	3.0	6.65%	6.39%	4.89%
Mortgage Backed	160.4	161.8	0.8	3.4	6.32%	6.05%	5.76%
Corporates	587.3	596.0	11.2	3.5	7.16%	6.66%	6.02%
Total	877.0	889.6	13.0	3.4	6.59%	6.38%	5.75%

(Amounts in millions)

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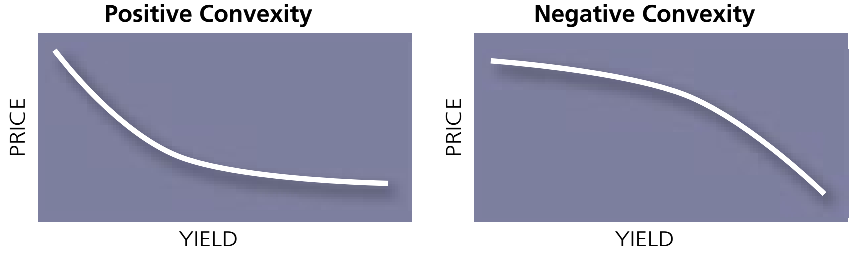
FIGURE 2



yields fall and that prices decline at a decreasing rate as yields rise.

The opposite is true for negative convexity. Both concepts are illustrated in the price/yield curves shown in Figure 2. Duration is closely related to the slope of the price/yield curve at a particular point (yield level). Convexity is closely related to the curvature of the price/yield curve, or the change in the slope.

If our insurer matched convexity as well as duration, it could further reduce its interest-rate risk. Since the insurance company follows only a duration-matched strategy, the durations of its assets and liabilities no longer match when rates change.

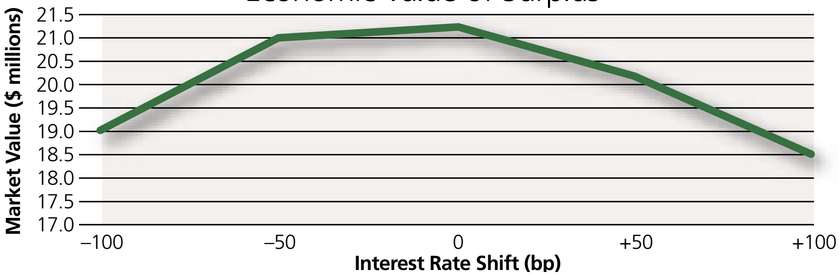
The difference in convexity between assets and liabilities can largely be attributed to the embedded options within the liabilities and in some of the assets. A look at various investment options explains how this concept works.

Deferred annuities. These contracts include a minimum interest-rate guarantee, which becomes more valuable when interest rates decline. This feature encourages policyholders to retain their contracts, thereby extending the duration when rates fall.

Deferred annuities often contain book-value withdrawal provisions whereby the policyholder can withdraw funds at book value regardless of what happens to interest rates. While deferred annuities typically have surrender charges to minimize the risk of disintermediation, charges decline over time and may not provide complete protection.

If interest rates rise significantly, renewal rates may become uncompetitive and policyholders may surrender their contracts earlier than expected, causing duration to shorten.

FIGURE 3 Economic Value of Surplus



	Interest Rate Shift (b.p.)				
Market value:	–100	–50	0	+50	+100
Assets (incl. accrued interest)	932.4	917.7	902.6	887.0	871.4
Liabilities	913.3	896.7	881.4	866.7	852.9
Surplus	19.1	21.0	21.2	20.3	18.5
Duration:					
Assets	3.2	3.3	3.4	3.5	3.6
Liabilities	3.9	3.6	3.4	3.3	3.1
Surplus	(29.4)	(7.4)	3.4	15.5	25.8
Convexity:					
Assets	(0.2)	(0.2)	(0.1)	(0.1)	0.0
Liabilities	1.1	0.6	0.3	0.2	0.2
Surplus	(58.0)	(32.7)	(18.4)	(12.9)	(7.3)

These embedded options result in liabilities that have high positive convexity. Highly convex liabilities will have higher economic value compared to less convex liabilities when interest rates change.

Mortgage-based securities. These investments have negative convexity. When interest rates decline, their duration tends to decrease due to prepayment provisions within the underlying residential mortgages. If rates rise, the opposite is true.

Callable bonds. Such bonds will have negative convexity as rates decline and the market price of the security approaches the call price.

Negatively convex assets will have lower economic values compared with more convex assets when interest rates change. When the convexity of assets is less than the convexity of liabilities, the economic surplus, as measured by the market value of assets less the market value of liabilities, will decrease if interest rates change, as illustrated in Figure 3.

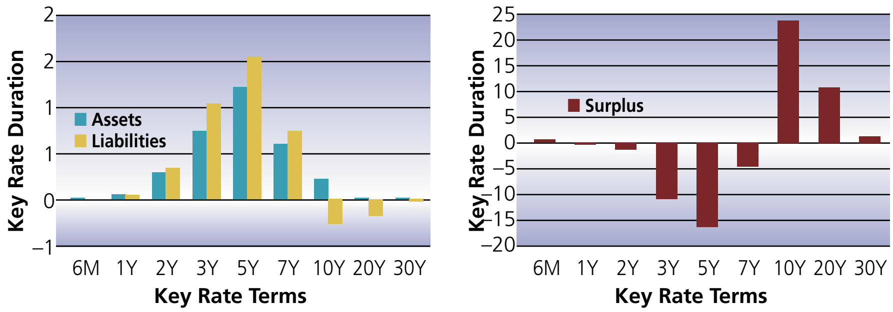
The convexity mismatch can be improved by replacing mortgage-backed securities and callable bonds with non-callable securities. Additional convexity can be added by buying interest-rate derivatives such as caps and floors. Ultimately, however, increasing the convexity of an asset portfolio will result in a lower yield.

Matching Key-rate Durations

The second limitation can be addressed by matching key-rate durations. These durations measure a security's sensitivity to changes in interest rates for each segment of the yield curve. The sum of the key-rate durations equals the effective duration for that security.

Our hypothetical insurance company uses nine key rates: 6-month, 1-year, 2-year, 3-year, 5-year, 7-year, 10-year, 20-year, and 30-year rates. Figure 4 shows the key-rate durations for the example annuity block. While the overall duration of the assets and liabilities is matched, the key-rate durations are not. As a result, our insurer is exposed to nonparallel yield curve shifts, with its greatest exposure to changes in the 10-year rate.

FIGURE 4 Key rate durations



	Assets	Liabilities	Surplus
6 months	0.02	0.00	0.81
1 year	0.11	0.11	–0.18
2 years	0.33	0.38	–1.25
3 years	0.79	1.08	–10.81
5 years	1.21	1.65	–16.14
7 years	0.65	0.78	–4.62
10 years	0.24	–0.36	24.02
20 years	0.04	–0.23	10.59
30 years	0.01	–0.02	0.98
Total	3.40	3.40	3.40

Economic surplus would decrease by 24 percent for each 1 percent increase in the 10-year interest rate. While selling 10-year-and-longer assets and reinvesting the proceeds in shorter duration assets improves the situation, liabilities have negative 10-, 20-, and 30-year key-rate durations. Only by short selling or using derivatives can our insurer match negative key-rate durations.

Liability Duration

Although implementing convexity and key-rate duration matching can enhance duration matching, limitations remain. The liability duration is sensitive to assumptions such as lapses, mortality, and morbidity.

In the case of our insurer's deferred annuities, the duration using "best estimate" assumptions is 3.4 years (see Figure 5), assuming no excess lapses result in a duration of 4.8. Increasing base lapses by 20 percent reduces the duration to 3.3; decreasing base lapses by 20 percent increases the duration to 3.5.

Changing mortality assumptions on the annuity block has only negligible impact for our hypothetical insurer. Obviously a change in mortality assumption would have a far greater impact for a life insurance block.

Changing the investment strategy to 100 percent 10-year assets increases the liability duration to 4.8. The duration for liabilities, whose credited rate is tied to the portfolio yield, will depend on the duration of the assets backing those liabilities. Shorter duration investment strategies will produce shorter liability durations. Conversely, longer duration investment strategies will produce longer liability durations.

Given the sensitivity of the liability duration to these assumptions, it can be difficult to establish appropriate duration targets for the asset portfolio.

Meeting Management's Objectives

The last limitation can't be overcome. Duration matching simply can't provide any insights into the risk/reward profiles of alternate investment strategies. Our insurer can overcome this hurdle, however, if it models the financial impact of alternate strategies over a set of stochastic scenarios.

Stochastic Modeling

If our hypothetical insurer wants to perform this type of analysis, it will have to generate "real world" economic scenarios. The generator used to create these scenarios has been calibrated to simulate yield-curve dynamics and correlations observed in the past.

The insurer must select mean reversion targets when modeling "real world" interest rates and inflation. These targets represent the long-run values these variables will tend to move toward.

Conning Asset Management typically bases mean reversion targets on historical norms when evaluating strategic investment strategies. One exception is inflation. We use the Federal Reserve's 2 percent inflation target as the basis for our mean reversion targets. With the 90-day Treasury rate historically averaging approximately 2 percent over the inflation rate, 4 percent is used as the mean reversion target for the 90-day Treasury. Since the term risk premium between the 90-day Treasury and the 30-year Treasury has historically averaged approximately 1.75 percent, we use a mean reversion target of 5.75 percent for the 30-year Treasury. Alternative mean reversion targets can be used to determine the robustness of the analysis.

Next, we identify the various investment strategies to be tested. We defined four alternate asset classes for our life insurer: 1-to-3 year, 4-to-6 year, 7-to-10 year, and 11-to-30 year bonds. Each maturity bucket includes a blend of non-callable corporate bonds. We then test different combinations of these four maturity buckets.

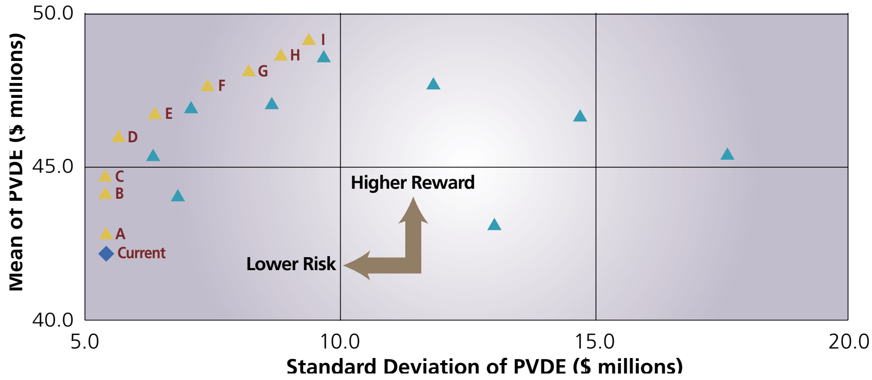
For each of the strategies, statutory balance sheets and income statements are projected along each interest-rate scenario and used to calculate distributable earnings, or free cash flows. Distributable earnings are defined as statutory earnings less the change in target surplus. Target surplus can be defined as a function of regulatory risk-based capital or one of the rating agency risk-based capital formulas.

Distributable earnings are then discounted using the risk-free rates for the corresponding scenario plus an appropriate spread. The spread may reflect the cost of capital or the target return on capital the company seeks. For a given strategy, we define our reward and risk measures as the mean and standard deviation of the results. The mean and stan-

FIGURE 5

Sensitivity Test	Economic Value ($ millions)	Effective Durations
Base case	$881.4	3.4
80% Base lapse rates	878.8	3.5
120% Base lapse rates	883.6	3.3
80% Mortality rates	881.1	3.4
120% Mortality rates	881.8	3.4
No Excess lapses	856.3	4.8
Longer duration investment strategy	893.7	4.8

FIGURE 5 Efficient Frontier



dard deviation for each strategy is then plotted on a risk/reward chart.

Next, we identify an efficient frontier comprising all strategies that maximize reward for a given level of risk. This enables our life insurer to narrow its search to strategies on the efficient frontier.

Figure 6 shows the efficient frontier for our hypothetical insurer's deferred annuities. Each point on the graph represents a different investment strategy. Points labeled A through I represent strategies on the efficient frontier. The solid triangles represent some strategies found to be inefficient.

Our company's current investment strategy is at the low-risk/low-reward end, which makes sense since it uses a duration-matched strategy that attempts to minimize interest-rate risk.

Other strategies on the efficient frontier result in higher reward but also higher risk. Some may be more appealing than the duration-matched strategy for our insurer, depending on its profit objective and risk tolerance.

Standard deviation isn't a perfect risk measure because it captures both positive and negative differences from the mean. As a result, we analyze the complete distribution of results.

Figure 7, which shows the distribution of results for all strategies on the efficient frontier, shows that the insurer's current duration-matching strategy has the lowest dispersion in results between the 5th and 95th percentile compared with other strategies on the efficient frontier.

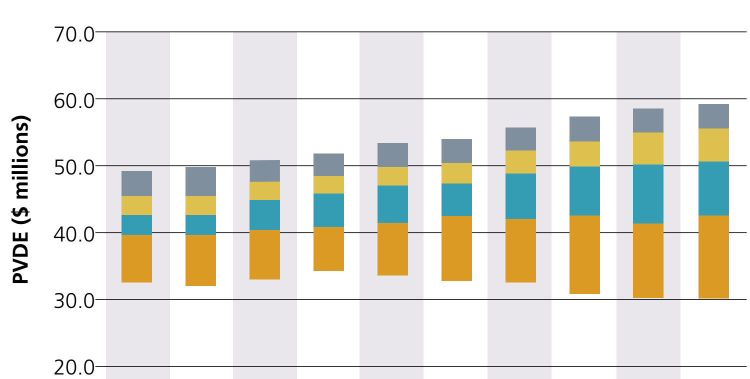
Efficient strategies with longer durations tended to have higher reward and higher risk. Strategies B, C, and D had higher expected profit at all percentiles than the current strategy. Strategies E through I had higher reward than the current strategy but more downside risk, as measured by the fifth percentile.

We then conduct sensitivity tests to determine whether the same strategies remain on the efficient frontier when different economic and actuarial assumptions are used. Frequently, strategies on or near the efficient frontier remain there when different assumptions are used.

Our hypothetical insurer may find such analysis very helpful in determining its appropriate strategic investment strategy. Rather than defining the optimal strategy in terms of duration, the insurer's optimal strategy is defined as allocations to maturity buckets. Once it selects the preferred strategy, it can create a benchmark and establish guidelines, within which the portfolio managers can operate.

To be sure, duration matching strategies can be reasonably effective at controlling interest-rate risk. However, if a company is interested in understanding the impact of alternate strategies on its financial results, stochastic modeling can quantify the distribution of possible outcomes. The results can then be analyzed within an efficient frontier framework to identify the optimal strategy that reflects the company's financial objectives and risk tolerance. ●

FIGURE 7 Distribution of Results



Strategy	Current	A	B	C	D	E	F	G	H	I
Asset Mix										
1–3 years	30	10	10	0	0	0	0	0	0	0
3–7 years	60	90	80	90	80	90	80	70	80	70
7–10 years	10	0	10	10	20	0	10	20	0	10
10–30 years	0	0	0	0	0	10	10	10	20	20
Asset Duration	3.4	3.5	3.8	4.0	4.2	4.4	4.7	4.9	5.1	5.3
Percentile:										
95%	49.9	50.5	51.7	52.5	53.6	54.8	56.2	57.3	58.4	59.4
75%	46.5	46.5	48.3	48.6	50.1	51.6	52.9	53.9	54.6	55.8
50%	43.4	43.9	45.6	45.9	47.5	47.7	49.1	50.3	50.4	51.5
25%	40.0	40.3	41.4	41.6	42.2	42.5	43.5	43.7	43.2	44.0
5%	33.2	33.0	33.9	35.6	34.7	33.0	32.9	31.0	30.5	30.4
Standard Deviation	5.4	5.4	5.5	5.5	6.1	6.8	7.9	8.3	8.6	9.4
Mean	42.7	43.2	44.5	44.9	45.8	46.4	47.2	47.8	48.2	48.8