Asset Liability Management
How Matched is this Company?

Karen (Schreiber) Fireman

U. S. F. & G., 100 Light Street, Baltimore, Maryland 21202, U. S. A.

Summary

Insurance companies are coming under increasing attack: by voters for premium levels, by Congress for the tax burden and by citizens action groups for solvency. We must continue to broaden our methods of evaluating and managing insurance companies. Asset/Liability Management is emerging as a useful tool.

This paper begins by reviewing Asset/Liability Management basics. The discussion is pragmatic rather than theoretical, presenting techniques in use.

A new method for evaluating the duration of inflation sensitive assets is presented. Then, by examining the inflation adjusted duration, the increased risk to surplus in an inflationary environment is shown.

Several sensitivity analyses are presented. Each changes the duration of a single variable and looks at the effect on surplus risk exposure. These variables are bond duration, real estate duration, and liability duration. The results are then combined into a two-way sensitivity matrix. Last, cash flow immunization is analyzed for mismatches.

This paper shows liability duration is sensitive to rising inflation. Surplus is hit twice, once by dropping asset values and again by increasing liabilities. Real estate and inflation sensitive special investments can ameliorate the impact. However, real estate behaves more like a medium term bond than an inflation hedge. Reducing the duration mismatch and adding inflation hedging instruments is prudent when inflation is expected to rise.

Résumé

Gestion des Actifs / des Engagements
Quelle est la Congruence de votre Société?

Les compagnies d'assurance sont de plus en plus attaquées: par les électeurs pour les niveaux de prime, par le Congrès pour la fiscalité et par les groupes d'action des consommateurs pour la solvabilité. Nous devons continuer à élargir nos méthodes d'évaluation et de gestion des compagnies d'assurance. La gestion des actifs/des engagements apparaît comme un outil utile.

Cet article commence par réviser les bases de la gestion des actifs et des engagements. La discussion est pragmatique plutôt que théorique et présente des techniques utilisées.

Nous présentons une nouvelle méthode pour évaluer la duration des actifs sensibles à l'inflation. Puis en examinant la duration ajustée par l'inflation nous montrons le risque accru sur l'excédent dans un environnement inflationniste.

Plusieurs analyses de sensibilité sont présentées. Chacune d'entre elles change la duration d'une seule variable et considère son effet sur l'exposition au risque d'excédent. Ces variables sont la duration de l'obligation, la duration des biens immobiliers, et la duration des engagements. Les résultats sont alors combinés en une matrice de sensibilité bidirectionnelle. Enfin, l'immunisation du cash-flow est analysée pour détecter les disparités.

Cet article montre que la duration des engagements est sensible à l'inflation ascendante. L'excédent est touché deux fois, une fois par les valeurs d'actif en baisse et à nouveau par les engagements croissants. Des placements spéciaux sensibles à l'inflation et en biens immobiliers peuvent améliorer l'impact. Cependant, les biens immobiliers se comportent davantage comme une obligation à moyen terme que comme une protection contre l'inflation. Il est prudent de réduire la disparité de duration et d'ajouter des instruments de protection contre l'inflation lorsque l'on s'attend à une hausse de l'inflation.

INTRODUCTION

The insurance industry is in a down-cycle. With strong competition, soft prices, cash flow way down, tax burden increasing, attention on junk bond and real estate portfolios, and Ralph Nadar's Public Citizen group sounding alarms about the insurance industry, it's prudent to take another look at solvency.

In many cases, people have ignored the questions underlying solvency: "How matched is this entity ? And, how much will it hurt not being matched ?"

Besides looking at NAIC ratios, actuaries and investment managers would be well served to manage the mismatch between their assets and liabilities.

The bottom line benefit is reduced risk to surplus. Better matched assets and liabilities results in the company being well positioned to take advantage of investment opportunities and premium pricing opportunities.

OVERVIEW OF ASSET/LIABILITY MANAGEMENT

Asset/Liability (A/L) Management is a relatively new tool for property/casualty (P/C) companies. It has been used in banking and for life companies for many years. Many people believe the liabilities of P/C companies are too ill- defined for use with A/L concepts.

Nothing could be further from the truth. Anytime cash flows can be identified, Asset/liability management can prove useful.

Asset/Liability management answers the question of how matched is a company and what is the potential result of the mismatch. Quantitative methods have been and are being developed to address cash flow matching, duration matching, dispersion matching, and convexity matching.

DEFINITIONS OF DURATION

There are many definitions of duration. This paper uses "Modified Duration." "Modified duration" is different than the vernacular usage (e.g. "I will be in the living room for the duration of my stay", which really means remainder.) It is also different than Macaulay's Duration which is a measure of maturity.

"Modified Duration" is a method of quantifying the interest sensitivity of a cash flow. It is described in Figure 1.

- Definition:Modified Duration
- Percentage change in Net Present Value (NPV) for a 1% increase in interest rates.

Example
- Duration = 3
- $100 million
- Interest Rates Increase 1%
- Resulting Value Drops to $97 million (i.e. value drops 3%)

Formula
- Modified Duration $= \sum\limits_{t} \dfrac{PV_t * t}{PV_t} \div [1 + r/2]$

Definitions
t	=	the time lapse in half years until tth cash flow,
PVt	=	the present value of the tth cash flow,
PV	=	the sum of the present value of all cash flows, and
r	=	the current interest rate used for discounting.

Figure 1. Modified Duration definition, example, and formula.

The concept of duration is not limited to assets. It can be applied to any stream of cash flows. The entire balance sheet is evaluated as shown in the simple example of Figure 2a. First one calculates the duration of the assets. Then, multiplying the duration times the value of the assets, one obtains the volatility exposure (also called interest rate exposure) of the assets. In this case, $8,800 x 3.2% = $282. The duration of liabilities and their interest rate exposure is calculated. In this case, $7,600 x 2.2% = $163. The duration of surplus is calculated differently. One subtracts the liability exposure from the asset exposure (e.g. $282 - $163 = $118) and divides the result by surplus (e.g. $118/$1,200 = 9.2%), yielding a surplus duration of 9.2, (not 1%). That is, if interest rates increase 100 basis points (or 1 percentage point), the net present value of assets will drop by $282, the net present value of liabilities will drop by $163, and netting, the value of surplus will drop by $118. This is shown graphically in figure 2b.

Duration Gap Analysis

Balance Sheet Account	Statement Value		Duration		Volatility Exposure
Assets	$8,800	*	3.2%	=	$282
Liabilities	7,600	*	2.2%	=	163
Surplus	$1,200				$118 = 9.2% duration of surplus

Figure 2a. Duration Gap Analysis requires calculating duration of assets and liabilities, resulting in volatility exposure of surplus and surplus duration.
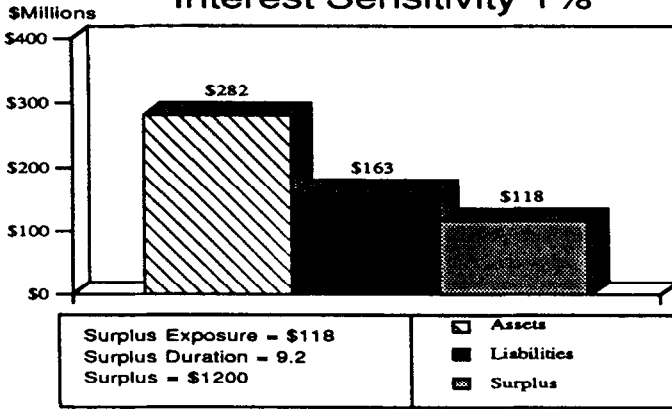

Figure 2b. Duration analysis provides volatility exposure of assets, liabilities and surplus.

HOW IS DURATION OF ASSETS CALCULATED ?

Assets can be classified into several major categories: bonds, equities, real estate, short term, special investments, and non-investable assets.

While there is much debate as to the duration of equities, the duration of the S&P 500 is often used as 4, for practical purposes. The duration of special investments and non-investable assets must be approximated based on cash flows or expected maturities. For example, if cash flows are expected to be like a 10-year treasury, one could approximate the duration by choosing 6, (i.e. the duration of a 10-year treasury.) If on the other hand, one expects varying cash flows, the duration formula should be used.

In some cases, duration calculations may need to be adjusted for special investment characteristics such as reduced interest rate sensitivity of municipal bonds.

HOW IS DURATION OF LIABILITIES CALCULATED ?

The actuarial accident year loss reserve payout pattern is applied to the reserves for each line of business. This enables one to "spread" the reserves into a cash flow series and then apply the duration formula. In this way, duration can be calculated for each line of business. Then cash flows are cumulated by accident year into a single cash flow from which the overall loss reserve duration is calculated. Finally, the unearned premiums must be added[1] [Babble]. Figure 3 shows an example of a duration calculation for personal automobile liability line.

To calculate the duration for unearned premiums (UPR), each line's loss ratio must be applied to isolate the portion of reserves for "spreading". Each resulting pattern of cash flows must be lagged an average of one-half year. These are then cumulated by accident year along with the loss reserve cash flows to obtain an overall loss duration of 2.2.

Other liabilities' expected cash flows are analyzed similarly to determine their duration.

HOW IS DURATION OF SURPLUS CALCULATED ?

As stated above, surplus duration is the result of subtracting the liabilities' interest rate exposure from the assets' interest rate exposure and then dividing by the surplus value. This surplus duration is usually many times the difference between asset and liability durations.

NEW METHODOLOGY FOR CALCULATING DURATION
OF INFLATION SENSITIVE CASH FLOWS

Another method of calculating duration was developed by the author for evaluating the effect of inflation on duration calculations. The method relies on discounting the cash flows several times as follows. First, a standard net present value (NPV) calculation is done using the current interest rate, r, for discounting.

INPUTS	INFLATION CHG	0.0%
	TOTAL PMTS	$100,000
RESULTS	MOD DUR	1.7

YEAR	PAYMENT SCHEDUL	PMT FOR LINE	PMT:INFL	PV(pmt)	WEIGHT	MOD DUR	PV(pmt)	PV(r+1%)
1	45.00%	$45,000	$45,000	43,165	0.5146	0.2573	43,165	42,959
2	20.00%	20,000	20,000	17,652	0.2104	0.3157	17,652	17,401
3	14.00%	14,000	14,000	11,370	0.1355	0.3389	11,370	11,101
4	6.50%	6,500	6,500	4,857	0.0579	0.2027	4,857	4,697
5	3.00%	3,000	3,000	2,063	0.0246	0.1107	2,063	1,976
6	2.00%	2,000	2,000	1,265	0.0151	0.0830	1,265	1,200
7	1.50%	1,500	1,500	873	0.0104	0.0677	873	821
8	1.20%	1,200	1,200	643	0.0077	0.0575	643	598
9	0.90%	900	900	444	0.0053	0.0449	444	409
10	0.60%	600	600	272	0.0032	0.0308	272	248
11	0.55%	550	550	229	0.0027	0.0287	229	208
12	0.50%	500	500	192	0 0023	0.0263	192	172
13	0.45%	450	450	159	0.0019	0.0237	159	141
14	0.38%	380	380	124	0.0015	0.0199	124	109
15	0.30%	300	300	90	0.0011	0.0155	90	78
16	0.26%	260	260	72	0.0009	0.0132	72	62
17	0.25%	250	250	63	0.0008	0.0125	63	54
18	0.19%	190	190	44	0.0005	0.0092	44	37
19	0.18%	180	180	39	0.0005	0.0085	39	32
20	0.15%	150	150	30	0.0004	0.0069	30	25
21	0.12%	120	120	22	0.0003	0.0053	22	18
22	0.10%	100	100	17	0.0002	0.0043	17	14
23	0.09%	90	90	14	0.0002	0.0037	14	11
24	0.08%	80	80	11	0.0001	0.0032	11	9
25	0.07%	70	70	9	0.0001	0.0027	9	7
26	0.06%	60	60	7	0.0001	0.0022	7	6
27	0.02%	20	20	2	0.0000	0.0007	2	2
28	1.00%	1,000	1,000	101	0.0012	0.0332	101	78
29	0.55%	550	550	51	0.0006	0.0174	51	39
30	0.00%	0	0	0	0.0000	0.0000	0	0
31	0.00%	0	0	0	0.0000	0.0000	0	0
32	0.00%	0	0	0	0.0000	0.0000	0	0
33	0.00%	0	0	0	0.0000	0.0000	0	0
34	0.00%	0	0	0	0.0000	0.0000	0	0
35	0.00%	0	0	0	0.0000	0.0000	0	0
	100.00%	$100,000	$100,000	83,880	1	1.7461	83,880	82,511

Figure 3. Example of duration calculation for liability line. Duration is 1.7

YEAR	PAYMENT SCHEDUL	PMT FOR LINE	PMT:INFL	PV(pmt)	WEIGHT	MOD DUR	PV(pmt)	PV(r+1%)
1	45.00%	$45,000	$45,810	43,942	0.5146	0.2573	43,165	43,733
2	20.00%	20,000	20,360	17,970	0.2104	0.3157	17,652	17,714
3	14.00%	14,000	14,252	11,574	0.1355	0.3389	11,370	11,301
4	6.50%	6,500	6,617	4,945	0.0579	0.2027	4,857	4,782
5	3.00%	3,000	3,054	2,100	0.0246	0.1107	2,063	2,011
6	2.00%	2,000	2,036	1,288	0.0151	0.0830	1,265	1,222
7	1.50%	1,500	1,527	889	0.0104	0.0677	873	835
8	1.20%	1,200	1,222	654	0.0077	0.0575	643	609
9	0.90%	900	916	452	0.0053	0.0449	444	416
10	0.60%	600	611	277	0.0032	0.0308	272	253
11	0.55%	550	560	234	0.0027	0.0287	229	211
12	0.50%	500	509	195	0.0023	0.0263	192	175
13	0.45%	450	458	162	0.0019	0.0237	159	144
14	0.38%	380	387	126	0.0015	0.0199	124	111
15	0.30%	300	305	91	0.0011	0.0155	90	80
16	0.26%	260	265	73	0.0009	0.0132	72	63
17	0.25%	250	255	64	0.0008	0.0125	63	55
18	0.19%	190	193	45	0.0005	0.0092	44	38
19	0.18%	180	183	39	0.0005	0.0085	39	33
20	0.15%	150	153	30	0.0004	0.0069	30	25
21	0.12%	120	122	22	0.0003	0.0053	22	18
22	0.10%	100	102	17	0.0002	0.0043	17	14
23	0.09%	90	92	14	0.0002	0.0037	14	11
24	0.08%	80	81	12	0.0001	0.0032	11	9
25	0.07%	70	71	9	0.0001	0.0027	9	7
26	0.06%	60	61	7	0.0001	0.0022	7	6
27	0.02%	20	20	2	0.0000	0.0007	2	2
28	1.00%	1,000	1,018	103	0.0012	0.0332	101	79
29	0.55%	550	560	52	0.0006	0.0174	51	40
30	0.00%	0	0	0	0.0000	0.0000	0	0
31	0.00%	0	0	0	0.0000	0.0000	0	0
32	0.00%	0	0	0	0.0000	0.0000	0	0
33	0.00%	0	0	0	0.0000	0.0000	0	0
34	0.00%	0	0	0	0.0000	0.0000	0	0
35	0.00%	0	0	0	0.0000	0.0000	0	0
	100.00%	$100,000	$101,800	85,390	1	1.7461	83,880	83,996

Figure 4. An inflation factor of 1.8% was applied to the line of business. The resulting duration changes from 1.7 to -0.1.

Next, the actuarial models are rerun with inflation assumptions 100 basis points higher than before, to obtain the amplification factor for the reserves. This is then applied to the cash flows. Figure 4 uses data from Figure 3 and applies an inflation factor of 1.8% to the cash flows in column 1 to obtain those of column 2. Then another NPV is calculated using the discount factor plus 100 basis points. The inflation adjusted duration equals the percentage change between the first and second NPV. In this case, duration equals -0.1%. Figure 5 summarizes the steps in the inflation adjusted duration methodology.

Inflation Adjusted Duration Methodology

1. Obtain cash flows

2. Calculate NPV_1 using current discount rate (r)

3. Inflate cash flows

4. Calculate NPV_2 using inflated cash flows and r+1

5. Duration = $\dfrac{NPV_1 - NPV_2}{NPV_1}$

Figure 5. The Inflation Adjusted Duration Methodology was designed to incorporate the effect of inflation on the cash flows, which typical modified duration calculations ignore.

IMPACT OF INFLATION ON DURATION CALCULATIONS

Increases in inflation reduce liability duration. They also reduce real estate duration, as well as reducing the duration of other inflation sensitive cash flows. Why ?

Consider liabilities. An increase in inflation causes claim payments to **increase**. The standard duration analyses which are **unadjusted** for inflation show **net present value(NPV)** of reserves **decreasing** as interest rates increase, but they do not adjust the cash flow stream itself for inflation. By adjusting these claim payments for inflation, we enable these effects to compete. The NPV of liabilities may indeed drop, but less than the unadjusted duration would predict. In extreme inflation, the claim payment increase will dwarf the drop from discounting, causing a **negative duration** and an **NPV increase**.

Deflation may present special difficulties. Will claims actually drop? Or will economic hardship increase claim payments ? Will reserve adequacy be questioned during periods of prosperity ? Will pricing aggressiveness be abandoned as interest rates drop ? These and other issues still need to be addressed.

RESULTS OF STUDIES

Two studies were done. The 1988 study is summarized briefly. Then this paper describes the 1990 study which expanded the 1988 study.

1988 STUDY
The company wanted to know whether it was matched and if not, how large was the mismatch.A duration analysis of the company was performed using accident year reserve analysis.

THE 1988 RESULT. A duration mismatch exists, but is not excessive. The liabilities have long tails, yet resultant duration is not long. However, holding long tax exempts, long treasuries and long corporates accentuates the mismatch.

1990 STUDY
The company recognized it had a mismatch and was concerned about the potential effect inflation would have on surplus. The company wanted to know what things it could do to protect itself. The 1990 study updated and enhanced the 1988 study. Cash flow was analyzed, liability duration updated, inflation effect analyzed, and the effect of real estate was analyzed.

THE 1990 RESULTS. Liability duration is sensitive to rising inflation. Surplus is hit twice, once by dropping asset values and again by increasing liabilities. Real estate and interest sensitive special investments can ameliorate the impact. However, real estate behaves more like a medium term bond than an inflation hedge. Reducing the duration mismatch and adding inflation hedging instruments would be prudent if inflation is expected to rise.

Specific areas of the 1990 study include:
(1) Bond Duration Sensitivity,
(2) Real Estate Duration Sensitivity and Inflation Effect,
(3) Liability Duration Sensitivity and Inflation Effect, and
(4) Cash Flow Immunization Gap.

BOND DURATION SENSITIVITY

The company wondered how much if any impact fixed income duration changes would have on the surplus volatility exposure. A bond duration sensitivity analysis was performed and is shown in figure 6.

THE BOND DURATION RESULT. Reducing fixed income duration has a significant beneficial impact on risk to surplus.

Why ? By reducing the duration of any asset, total asset duration is decreased, and the gap between asset and liability duration diminishes as does the surplus volatility. Fixed Income comprises over 50% of the portfolio. Reducing (or increasing) its duration, even slightly, has a greater leverage effect on the duration of surplus than any other asset class.

The sensitivity analysis in figure 6 shows this impact of varying the fixed income duration while keeping duration of other assets and liabilities fixed. The chart shows the impact on
  a) duration of all invested assets,
  b) duration of total assets (including non-invested),
  c) duration gap,
  d) duration of surplus, and
  e) interest sensitivity of surplus.

Looking at figure 6, the current bond duration is 4.1, surplus duration is 9.2 surplus volatility is $118 million. Suppose bond duration were reduced from 4.1 to 3.0 by shortening the portfolio's average maturity, or swapping low coupon bonds for high ones. Surplus exposure would drop $45 million: from $118 million to $73 million.
This reduction of surplus risk is due entirely to the reduced exposure of bonds to changes in interest rates as shown in column two. Bond volatility drops from $169mm to $123mm, thereby reducing surplus duration to 5.7% and surplus volatility to $73mm.

BOND DURATION SENSITIVITY ANALYSIS

DURATION OF BONDS	VOLATILITY OF BONDS	DURATION OF LIABILITIES	DURATION OF INVESTED ASSETS	DURATION GAP	DURATION OF SURPLUS	VOLATILITY OF SURPLUS
3.0	$123	2.2	3.0	0.5	5.7	$73
4.1	$169	2.2	3.6	1.0	9.2	$118
5.0	$206	2.2	4.1	1.4	12.1	$155

Figure 6. Bond Duration Sensitivity Analysis shows the impact of changing the duration of the bond portfolio. Duration of surplus and volatility exposure of surplus are dramatically effected.

REAL ESTATE DURATION SENSITIVITY AND INFLATION EFFECT

The company has a substantial real estate and mortgage loan portfolio, and wondered how much benefit the real estate would provide in high inflation. The cash flows for a typical mortgage loan were analyzed, and then the sensitivity analysis was performed.

THE REAL ESTATE RESULT. Real estate typically appreciates with inflation, but real estate's ability to meet an insurance company's inflation hedging needs is limited by its long duration, its illiquidity and its small weight in the investment portfolio. Can real estate provide cash when the company needs it to combat inflation ?

Why is a mortgage loan's duration long ? Figure 7 shows projected cash flows of an actual property which was analyzed. An initial investment of $12mm was made in year 0 and is being followed by income receipts between $1.3mm to $1.6mm in years 1-7. In year 8, the property is expected to be sold for a total of $21mm. This payment stream looks remarkably like a bond ! In fact the duration is similar to that of an 8-year bond.

REAL ESTATE DURATION ANALYSIS

MODIFIED DURATION 5.4

YEAR	CASH FLOW	PV	WEIGHT	MOD DUR	PV(r)	PV(r+1)
0	(11,995)					
1	1,287	1,236	0.0653	0.0	1,236	1,230
2	1,443	1,277	0.0675	0.1	1,277	1,259
3	1,523	1,243	0.0656	0.2	1,243	1,213
4	1,375	1,034	0.0546	0.2	1,034	1,000
5	1,472	1,021	0.0539	0.2	1,021	978
6	1,539	984	0.0520	0.3	984	933
7	1,607	947	0.0500	0.3	947	890
8	20,595	11,191	0.5911	4.4	11,191	10,415
	30,841	18,933	1	5.4	18,933	17,919

Figure 7. Projected cash flows of an actual property were analyzed. The payment stream looks like an 8-year bond. Duration is calculated as 5.4.

What happens to real estate duration as inflation increases ? **Increases in inflation reduce real estate duration.** Why ? Inflation increases rental revenues and the eventual property sale price. Simultaneously, the discount rate increases for discounted cash flow calculations. These effects compete, the net effect is a drop in the duration.

Figure 8 shows the results of a real estate sensitivity analysis. If inflation is increased 200 basis points above its current level, real estate duration drops from 5 to 3.1

REAL ESTATE INFLATION SENSITIVITY ANALYSIS

R E A L E S T A T E	Inflation Change	Real Estate Duration	Surplus Change
	+600 bp	-0.7	$46
	+400bp	1.2	$31
	+200bp	3.1	$15
	+100bp	4.2	$7
	no change	5.4	$0

Figure 8. Real Estate's appreciation with inflation will not help surplus very much. As inflation increases 200 basis points from current levels, real estate duration drops from 5.4 to 3.1 with only a $15 beneficial impact on surplus.

LIABILITY DURATION SENSITIVITY AND INFLATION EFFECT

The company was concerned about inflation. It wanted to quantify the inflation effect on liabilities as well as on assets and finally on surplus.

THE LIABILITY RESULT. Increases in inflation reduce liability duration. Why ? An increase in inflation causes claim payments to increase. An increase in inflation also causes the discount rate to increase, decreasing the net present value. These effects compete causing duration to drop. In extreme inflation, the duration will become negative as the claim payments dwarf the NPV discounting.

Figures 9a and 9b show the effect of changing inflation on the duration of liabilities. If inflation increases 200 basis points above its current level, liability duration will drop from 2.2 to 0.3.

While decreasing duration is beneficial for an asset, it is disadvantageous for a liability. The decline in the duration of assets reduces risk to surplus, while a decline in liability duration increases risk to surplus.

LIABILITY DURATION & INFLATION SENSITIVITY ANALYSIS

inflation change	+300bp	+200bp	+100bp	no change	-100bp	-200bp
LIABILITY DURATION	-0.6	0.3	1.3	2.2	3.3	4.2
CHANGE IN SURPLUS VOL.	$797	$372	$59	$0	$-72	$-141
SURPLUS VOLATILITY	$915	$490	$177	$118	$46	$-23

Figure 9a. Liability Duration is dramatically affected by inflation. An increase of 200 basis points above the current level causes liability duration to drop from 2.2 to 0.3 with surplus volatility exposure of $490.

Duration Analysis
Interest Sensitivity 1%

$Millions

$400
$300 — $282
$200 — $163
$100 — $118
$0

Surplus Exposure = $118
Surplus Duration = 9.2
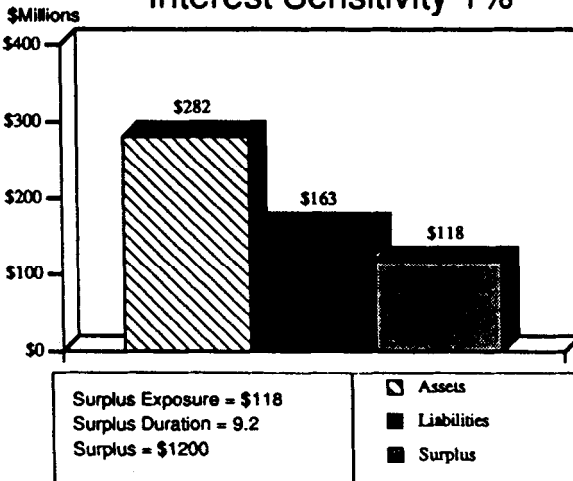Surplus = $1200

▨ Assets
■ Liabilities
▨ Surplus

Figure 2b. Duration analysis provides volatility exposure of assets, liabilities and surplus.

Figure 10 is a two-way table summarizing inflation effects on (1) real estate duration, (2) liability duration, and (3) ultimately surplus exposure. As inflation changes from its current level, the interior of the table shows the change in surplus volatility exposure from its current level of $-118 million. (In this chart a large surplus volatility exposure is bad.)

This table makes it possible to look at both general inflation effects on claim payments and real estate inflation effects. This is important since the effect on real estate may be quite different than on claims. The rows of the table represent change of general inflation from current levels. The columns are changes of real estate inflation from current levels.

Looking at figure 10, if real estate inflation increases 200bp, while general inflation affecting liabilities only increases 100bp from current levels, figure 10 shows that surplus volatility exposure will deteriorate by an additional $44 million for a total of $162 million.

Remarkably, the effect on surplus of merely a 100bp increase in general inflation cannot be compensated for by even a 600bp increase in real estate inflation (which causes real estate duration to be negative.) At best, the surplus exposure would deteriorate by another $13mm beyond the current level, for a total of $131 million.

INFLATION SENSITIVITY ANALYSIS MATRIX
REAL ESTATE vs LIABILITY

CHANGE IN SURPLUS VOLATILITY EXPOSURE ($millions)

			GENERAL INFLATION CHANGE					
			+300 bp	+200 bp	+100 bp	no change	−100 bp	−200 bp
			CORRESPONDING LIABILITY DURATION					
			−0.6	0.3	1.3	2.2	3.3	4.2
R	Infl. Chg.	Duration						
E								
A	+600 bp	−0.7	$659	$280	$13	($46)	($118)	($232)
L								
	+400bp	−1.2	$705	$311	$29	($31)	($103)	($202)
E								
S	+200bp	3.0	$751	$341	$44	($15)	($88)	($171)
T								
A	+100bp	4.1	$775	$358	$52	($7)	($80)	($155)
T								
E	no change	5.0	$797	$372	$59	$0	($72)	($141)
	Current surplus volatility:			($118) mm				

Figure 10. Inflation sensitivity matrix shows the change in surplus exposure due to changes in general inflation or real estate inflation.

Typical in an Asset/Liability analysis, the company wanted to know how matched were its cash flows and where were the mismatches.

A cash flow immunization analysis was performed on a static liquidation basis. This considers only assets existing on the books and reserves for premiums already written. Figure 11 presents a bar chart summarizing this analysis.

On the asset side, interest income and dividends have been included, but for an ongoing entity, equities should be excluded unless sales are planned.

On the liability side, expected claim payments are based on the liability analysis previously discussed. A buffer has been added for adverse loss development, as well as one year of dividends and expenses, representing claims to be paid from invested assets.

THE CASH FLOW RESULT. In year one, there is a mismatch which could be made up by cash from new premiums, or by swapping some longer term assets for shorter ones. While this paper does not explicitly incorporate future business rollover, a portion of the mismatch is assumed to be covered by future premiums.

In fact, some studies suggest including future business in both the cash flow analysis and duration analysis. However, a "do nothing" strategy of maintaining a large mismatch is really cash flow underwriting. The difficulty with including future business in the analysis is the unknown pricing of that business, and unknown payout patterns.
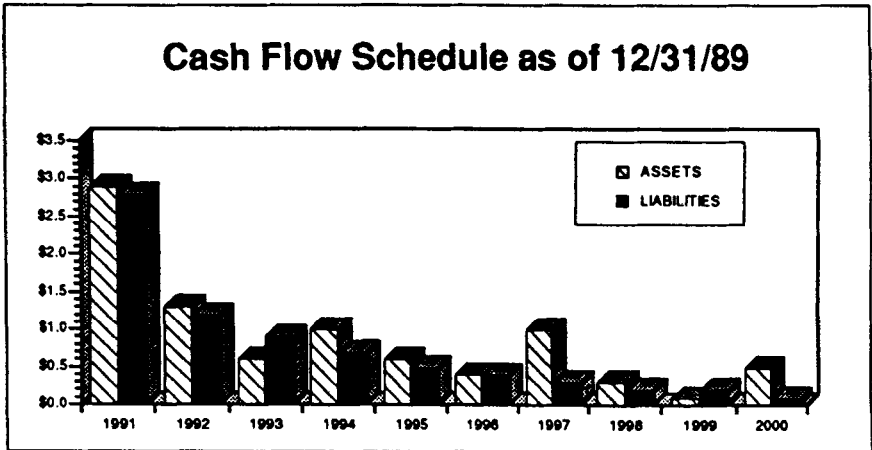

Figure 11. Cash Flow Immunization compares expected cash receipts with expected outlays. The first ten years are shown.

* Inflation and interest rate increases projected.
* Rollover of future business can cover modest cash flow mismatches.
* Statutory surplus risk tolerance of $120 million.
* Borrowing rate of 8.5%,
* Mastersons Medical inflation index used for long tail liability lines.
* Inflation rate increase of 100 basis points assumed to correlate with an interest rate increase of 100 basis points.

CONCLUSIONS

The asset/liability mismatch should be monitored and a target level set. Equity and junk bond effect on surplus risk exposure should be monitored. Interest rate changes, duration mismatch, and cash flow mismatch should be analyzed for asset allocation implications.

The bottom line benefit is reduced risk to surplus, better matched assets and liabilities, and a better positioned portfolio to take advantage of investment and premium pricing opportunities. Without the recommended changes, near term cash flow mismatches will be hard to rectify in a high interest rate environment; and cash flow underwriting can rob future profitability.

RECOMMENDATIONS

* Develop and implement a plan for an increasing inflation scenario.
* Reduce asset duration:
    - Shorten fixed income portfolio;
    - Purchase inflation hedges;
    - Invest in short term variable-rate instruments; and
    - Invest new premium dollars at durations which match product liability models.

ANNOTATED BIBLIOGRAPHY

[1] **Babble**, David F., Klock, David R., Polachek, Paul V., *Assessing the Interest Rate Risk of Property and Casualty Companies*, (New York: Goldman Sachs, 1988). Provides a hands on description of how to do Asset/Liability Management. This was referenced as the basis of the duration analysis methods used in this paper's 1988 study.

[2] **Butsic**, Robert P., *Evaluating Insurance Company Liabilities*, 1988 CAS Discussion Paper Program. The paper includes an innovative idea of reducing the discount rate below treasuries for uncertain cash flows such as liabilities.

[3] **Leibowitz**, Martin L., Sorensen, E. H., Arnott, R. D.,Hanson, H. N. , *A Total Differential Approach to Equity Duration*, (New York: Salomon Brothers, Inc., n.d.) This paper discusses equity duration calculations and points out that traditional calculations result in too high a result.

[4] **Leibowitz**, Martin L., *Horizon Matching: A New Approach to Dedicated Portfolios*. Journal of Portfolio Management 11 (Fall 1984). This paper discusses the need to maintain close matching for the next five years while being less matched for the longer term.

[5] **Norris**, Peter D., *Asset/Liability Management Strategies for Property & Casualty Companies*, Morgan Stanley, May 1985. One of the earlier discussions of Asset/Liability techniques for Property/Casualty Companies. Included is a discussion of market value analysis of assets, liabilities, and surplus.

[6] **Woll**, Richard G., *Insurance Profits: Keeping Score*, CAS 1987 Discussion Paper Program. This paper discusses insurance company profitability, including how much a company needs to invest to have enough funds to pay off claims, and the necessity of using only the risk free rate when calculating underwriting profits.