ASSET LIABILITY MATCHING FOR PROPERTY/CASUALTY INSURERS

by Sholom Feldblum

BIOGRAPHY:

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ABSTRACT:

Asset-liability matching, long known to life insurers, is currently being investigated by casualty actuaries. Several crucial differences between life and non-life insurance operations require modification of traditional immunization and duration matching techniques when applied to Property/Casualty insurers:

1. Life insurance liabilities are expressed in nominal terms; Property/Casualty insurance liabilities are inflation sensitive. Inflation sensitive liabilities are similar to short duration assets with regard to the effects of interest rate fluctuations.

2. With a normal, upward-sloping yield curve, short duration bonds provide lower returns than long duration bonds provide. In other words, duration matching with fixed income securities would reduce investment returns for Property/Casualty insurers.

3. Common stock prices vary directly with expected inflation, in contradistinction to bond prices, which vary inversely with expected inflation. Thus, both common stocks and Property/Casualty insurance liabilities are inflation sensitive.

4. Property/Casualty insurers do not segment funds, expect a steady premium inflow, and do not face disintermediation problems. Losses and expenses are generally paid from insurance cash flows, not from liquidation of assets.

5. On statutory financial statements, amortized bonds show little price fluctuation. But when marked-to-market, long-term bonds are risky assets.

A superficial acquaintance with asset/liability matching theory would indicate a short duration fixed income asset portfolio to back a Property/Casualty insurer's liabilities. A more careful consideration of the factors listed above indicates a portfolio of equity securities and long-term bonds. **

** I am grateful to Benjamin Lefkowitz and Richard Woll for extensive corrections to an earlier [illegible] of this paper. The remaining errors, of course, are my own.

ASSET LIABILITY MATCHING FOR PROPERTY/CASUALTY INSURERS

Asset-liability matching has long been known to life insurers and pension plan managers. Casualty actuaries now wonder whether it can improve their companies' stability as well. The answer is complex. Cash flows, interest rate changes, and risk influence both liabilities and assets. But the standard life insurance techniques of immunization and duration matching must be applied differently to Property/Casualty companies.

I. THE ASSET LIABILITY MATCHING PROBLEM

Why is interest growing in asset-liability matching? If a life insurer's writings are large and stable, and its investment returns are steady, then its profits will depend primarily on internal pricing and external competition. But complications arise when interest rates change. If rates decrease, the insurer's investment income may be insufficient to satisfy its policy obligations. If rates increase, insureds may take policy loans or lapse their policies to obtain higher investment returns elsewhere. The insurer may be forced to sell bonds at capital losses to meet its cash needs. Clearly, these scenarios will adversely affect operating returns.

Life insurers have responded to these uncertainties in three ways: (1) Some insurers are promoting term policies instead of permanent policies. The short duration of term policies reduces interest rate risk. (2) Some insurers are shifting investment reward and risk to the policyholder through variable and universal insurance policies and annuities. (3) And some insurers are matching durations and cash flows of liabilities and assets to mitigate the effect of interest rate fluctuations on operating returns.

Characteristics of Property/Casualty Insurers:

For first-party coverages, insurers pay claims soon after the accident date. In this regard, such Property/Casualty policies are similar to term life insurance. In the past two decades, however, the long tailed commercial liability lines - General Liability, Products Liability, Medical Malpractice, Commercial Auto Liability, and Commercial Multiple Peril - have grown in importance. The average loss in these lines is paid about four years after the accident date. Moreover, the investment risk on the assets supporting the loss reserves can not be shifted to policyholders. For these reasons, insurers seek ways to match their investment and insurance portfolios.

Property/Casualty companies have begun to investigate the life insurance repertoire of immunization techniques. High interest rates and slow loss payout patterns have made investment strategy vital to a liability insurer's operating profitability. Actuaries must now examine cash flow patterns in addition to loss frequencies and severities when pricing liability products. But there are several crucial differences between the characteristics of Property/Casualty and life insurance operations:

(1) Traditional life insurance and pension fund liabilities are expressed in nominal terms. For instance, a deferred annuity may obligate the insurer or pension fund to pay $500 a month for the insured's lifetime beginning at age 65. Casualty loss obligations, however, are determined at the settlement date. Inflation between the accident and settlement dates influences the ultimate liability. In other words, Property/Casualty liabilities are inflation sensitive. When inflation rates rise, liabilities increase, whereas the market values of long-term bonds decline. The reverse is true when inflation rates fall.

(2) Asset-liability matching involves holding an asset portfolio whose duration equals the duration of the liabilities. For the Property/Casualty insurer, this means short duration assets whose returns also vary directly with inflation, such as Treasury bills and commercial paper. But with a normal, upward-sloping yield curve, these assets have lower returns than do long duration assets, such as corporate bonds. Clearly, one must balance the benefits of immunization with the overall portfolio yield.

(3) Many actuaries and financial analysts ascribe long durations to common stocks. This seems true if one examines only the cash flows resulting from current and expected dividends, but not price changes or expected dividend changes due to changes in interest rates. However, common stock prices are inflation sensitive, just as insurance liabilities are. A rise in interest rates depresses bond prices. But after an initial period of a few weeks to a year, a rise in interest rates generally [illegible] common stock prices.

In sum, common stocks and liability insurance reserves are similar. Both are sensitive to inflation between the acquisition/occurrence and the disposal/payment dates. Asset/liability matching risk stems from factors other than interest rate changes. For common stocks, the principal factor is systematic stock market fluctuations. For insurance liabilities, the principal factors are contagion risks and changes in legal interpretation of coverage.

(4) Property/Casualty insurers do not face the same disintermediation problems that life insurers face. Regardless of interest rate changes, Property/Casualty insurers expect a steady stream of premium inflow. Moreover, Property/Casualty insurers do not segment funds. Investment returns must be sufficient for the company as a whole, not for any given block of policies.

(5) Measurements of asset risk often concentrate on nominal returns. For example, long-term bonds with amortized book values show high and steady nominal returns. But except for statutory financial statements, Property/Casualty insurers depend upon real returns. By this measure, long term bonds are risky assets.

Property/Casualty insurers have a difficult balancing act. The effects of inflation between the accident and settlement dates mean that loss reserves vary directly with interest rates. Immunization theory for fixed income assets recommends holding short-term bonds. But these securities have lower yields than long-term bonds have. Moreover, interest rates have a minor influence on insurance cash flows, since premium income does not vary greatly with investment returns for most lines of business. As a result, insurers invest heavily in long-term bonds, which are risky assets when marked-to-market. Yet insurers do not want to add investment risks to the fluctuations of the insurance underwriting cycle.

A common solution is to diversify into equity investments, such as common stocks and real estate. Real estate holdings are limited by state statutes, they are illiquid, and they require considerable investment expertise. Common stocks must be reported at their market values on Annual Statements, so their book values fluctuate more than those of bonds do. Long-term bonds therefore are the investment of choice for the Property/Casualty industry, accounting for about half of admitted assets.

Were bonds reported on the Annual Statement at their market values, instead of amortized values, their actual riskiness would be apparent, and insurers would invest more heavily in common stocks. In other words, accounting rules influence security selection as much as operating income does.[1]

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[1] Federal income tax laws also influence financial portfolios. Tax law changes affect asset holdings in ways that asset/liability matching theory does not recognize. The 1986 federal income tax modifications provide several examples:

(A) The tax rate on long term capital gains used to be lower than the rate on net investment income. Current law taxes both equally. As a result, growth stocks have lost their tax advantage over income stocks and corporate bonds.

(B) The reduced tax exemptions for municipal bond and corporate dividend income reduces the tax advantages of these securities over corporate bonds, federal bonds, and growth stocks.

(C) The strengthening of the Alternative Minimum Tax rules reduces the tax advantages of municipal bonds and income stocks over corporate bonds, federal bonds, and growth stocks.

Asset selection depends on current tax law as much as it does on the liability portfolio. Nevertheless, taxes are ignored in this paper, because tax laws

II. NOMINAL VERSUS INFLATION SENSITIVE LIABILITIES

Asset/liability matching theory is grounded on two characteristics of conventional life insurance policies: nominally valued liabilities and disintermediation. First, traditional life insurance liabilities are stated in nominal terms, but are funded at least partially by investment returns. If the assumed interest rate used for pricing the policy is "conservative" enough - that is, if it is sufficiently below actual investment returns - interest rate changes pose little risk. But investment returns have become more volatile in recent years, and competitive pressures have forced insurers to be less conservative in their interest rate assumptions. Consequently, interest rate changes have a large effect on life insurance profitability.

Second, many actuaries believe that life insurers faced strong disintermediation risks in the 1970's. Although this view is not correct, it characterized life insurers as financial underdogs, and so was widely accepted in the industry. (See below for further discussion of this.) In any case, disintermediation does not apply to Property/Casualty insurers, because the policy terms are short and policy reserves do not accumulate.

There is a sharp contrast between a life insurer with nominal liabilities and a Property/Casualty insurer with inflation sensitive liabilities. The life insurer may issue a $100,000 policy for a level net premium of $1,000 per

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change frequently and unexpectedly. This paper concentrates on the continuing characteristics of the Property/Casualty industry. However, actuaries must be cognizant of factors such as tax treatment and accounting regulations when providing financial investment recommendations.

annum. Policy exclusions (e.g., war and insurrection), a sufficient spread of risk to eliminate contagion factors (e.g., epidemics), and a large enough insurance portfolio of homogeneous insureds make the mortality risk insignificant for young applicants.

But interest rate risk remains. The $1,000 net annual premium may have been determined for a 5% per annum return on policy reserves. If interest rates fall below 5%, investment returns may not cover the expected loss.

Surprisingly, the converse can also occur: a drop in interest rates may benefit the insurer. Suppose an insurer issued a one year annuity certain on January 1, 1987 for $1,000; new money interest rates were 10% per annum; and the annuity paid $1,100 on January 1, 1988. Moreover, suppose the insurer bought a 10-year corporate bond that paid 10% annually to fund the annuity.

What would happen if interest rates fell to 5% per annum during 1987? New corporate bonds issued on January 1, 1988, would pay 5% coupons. The insurer's old bond, which has 10% coupons, would be worth more than its par value. Its market price on January 1, 1988, would be the present value of the cash flows discounted at 5%, or

$$\text{Price} = \$100 + \$100 * 0.952 + \$100 * 0.952^2 + \ldots + \$1,100 * 0.952^9 = \$1,455.$$

In other words, the insurer could sell the bond for $1,455 on January 1, 1988, pay $1,100 to the annuitant, and pocket the remaining $355. Of course, the insurer can lose as easily as it can gain from interest rate changes. The reason is that its liabilities are fixed in nominal terms, but its investment returns fluctuate with interest rate changes. When a change in new money interest rates affects the market values of liabilities and assets differently, the liabilities and assets are "mismatched." The greater the mismatch, the greater the interest rate risk.

Note that this is a speculative risk, not a pure risk: the insurer can gain as well as lose from interest rate changes. An aggressive insurer, confident of its ability to forecast interest rate changes, may consciously seek an asset/liability mismatch. A conservative insurer would attempt to match assets and liabilities more closely.

Matching Techniques:

Two common methods of matching assets and liabilities are cash flow matching and duration matching. Exact cash flow matching creates an asset/liability portfolio impervious to interest rate changes. The insurer forecasts net insurance cash flows from its book of business and buys fixed income securities whose coupons and maturities provide the needed monies at the needed times. For instance, if the insurer estimates that its net insurance cash outflow 10 years hence will be $5,000,000, it would arrange its financial portfolio such that coupons plus maturities provide $5,000,000 in that year.

Exact cash flow matching can be cumbersome, inefficient, and costly. One bond may closely match liability cash flows, but an alternative bond may provide a better yield. Interest rate changes are a speculative risk for the insurer, not simply a possibility of loss. Exact cash flow matching is worthwhile only when the benefits of risk reduction outweigh the costs of lower yields and administrative expenses. This is rarely the case.[2]

Duration Matching:

Duration matching hedges against small interest rate changes. A change in new money interest rates has two effects on bond prices. First, coupons are reinvested at the new money interest rate. When interest rates rise, the coupons are reinvested at higher returns. When interest rates fall, coupons are reinvested at lower returns. Second, the bond's price declines when interest rates rise and rises when interest rates fall.

If a fixed income security is used to fund a nominal liability, then the relative importance of changes in reinvestment returns and prices depends on the bond's term, its coupons, and the date of the liability payment. If a nominal liability of $1,100 is due at the end of the first year, then there is no reinvestment of coupons. The only change in the bond's total value results from the price change. In the illustration used above, the insurer gains the entire $355 price increase.

At a bond's expiration date, only the par value is received. Interim price changes have no effect on the proceeds. But reinvestment rate changes do

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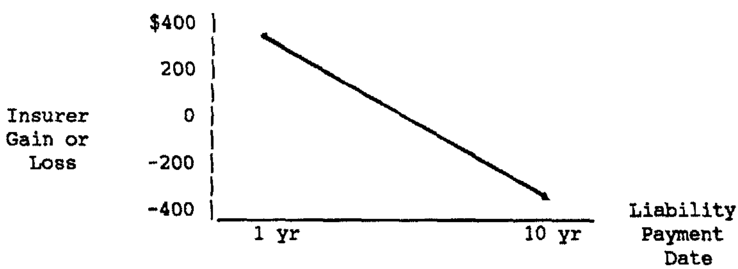
[2] See, for example, Martin L. Leibowitz and Alfred Weinberger, "Optimal Cash Flow Matching: Minimum Risk Bond Portfolios for Fulfilling Prescribed Schedules of Liabilities" (New York: Salomon Brothers, Inc., n.d.).

influence the final wealth.

Suppose a 10 year bond were used to fund a nominal liability of $2,594 due in 10 years. If interest rates remain at 10% per annum, the $100 annual coupons, together with the $1,000 par value of the bond, accumulate to $2,594 at the end of 10 years. But if new money interest rates fall to 5% per annum in the first year, the accumulated value of the coupons plus the maturity value declines to $2,258. The insurer will lose $336 - the difference between the nominal liability and the final wealth.

There is one date when the change in the bond's market value just balances the change in its reinvestment returns, as illustrated in Figure 1.

Figure 1: Insurer Gain or Loss
From an Interest Rate Change



10 year 10% annual coupon bond; interest rates decline to 5% during first year.

Thus, if the liability payment date is one year from purchase of the bond, the insurer gains. If it is ten years from the date of purchase, the insurer loses. If it is approximately five years from the date of purchase, the insurer just breaks even.

Macaulay Duration:

The point at which the positive and negative effects of a small change in interest rates just balance is the "Macaulay" duration of the bond. Formally, the Macaulay duration of a bond, or of any group of assets or liabilities, is the weighted average of the cash flow dates, where the weights are the present values of each cash flow.

Consider a 10 year 10% annual coupon bond issued on January 1, 1988. The cash flows consist of the $100 coupon payments each January 1, and the $1,000 principal repayment on January 1, 1997. The present values of the cash flows depend upon the current yield; figure 2 illustrates for yields of 10% and 5%.

Figure 2: Bond Duration

Date	Years Since Issue	Coupon Payment	Principal Repayment	Present Value at: 10%	5%
1/1/88	1	$100	0	$ 90.9	$ 95.2
1/1/89	2	100	0	82.6	90.7
1/1/90	3	100	0	75.1	86.4
1/1/91	4	100	0	68.3	82.3
1/1/92	5	100	0	62.1	78.4
1/1/93	6	100	0	56.4	74.6
1/1/94	7	100	0	51.3	71.1
1/1/95	8	100	0	46.7	67.7
1/1/96	9	100	0	42.4	64.5
1/1/97	10	100	1,000	424.1	675.3
Total				$1,000.00	$1,386.20

(10 year 10% annual coupon bond; current yield rates of 10% and 5% per annum.)

At a 10% current yield, the bond's duration is

(1*90.9 + 2*82.6 + . . . + 10*424.1) / (90.9 + 82.6 + . . . + 424.1) = 6.76 yrs.

At a 5% yield, the duration is

(1*95.2 + 2*90.7 + . . . + 10*675.3) / (95.2 + 90.7 + . . . + 675.3) = 7.29 yrs.

Suppose the bond were purchased to fund a nominal liability of $1,905 due in 6.76 years. Then a small change in interest rates - say to 10.2% or 9.8% - would cause no net gain or loss, because the change in market price would balance the change in reinvestment income.

The duration of two bonds is the weighted average of their individual durations, where the weights are the current market prices.[3] You can match assets and liabilities by equating their (overall) durations. First determine the duration of the liabilities, either by examining the total annual cash flows or by computing the weighted average of the durations of all policies. Then purchase fixed income securities whose overall duration matches the duration of the liabilities.

Duration matching eliminates asset/liability mismatch risk only for small interest rate changes. As the rates change, the bond durations change too, as shown in Figure 3.

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[3] More precisely, the weights are the sums of the discounted values of each bond's cash flows. Barring marketplace imperfections, these are the market prices of the bonds.

Figure 3: Bond Duration versus Current Yields
(10 year 10% annual coupon bond)

Current Yield	Duration	Current Yield	Duration
10%	6.76 yrs	7%	7.07 yrs
9	6.86 yrs	6	7.17 yrs
8	6.97 yrs	5	7.27 yrs

Even when the asset and liability portfolios have the same duration at one interest rate, they may have different durations at another. Fortunately, interest rates generally change slowly, giving the insurer time to "rebalance" its asset portfolio.[4]

Duration Matching for Property/Casualty Insurers:

If duration matching reduces mismatch risk for life insurers, does it work for Property/Casualty insurers as well? To find out, you must first determine loss payout patterns by line of business. Such data are available either from internal company reports or from statutory Annual Statements. Some analysts have used this data to estimate insurance portfolio durations.[5]

[4] Durations of whole life policies generally exceed the durations of long-term bonds. This complicates duration matching. Moreover, rebalancing the asset portfolio may be difficult when interest rates change sharply. To solve these problems, some financial analysts have suggested taking long positions in futures and buying call options to lengthen the duration of the asset portfolio. In practice, however, unless there are other reasons for investing in futures and options (such as hedging), the additional cost of these transactions outweighs the gains from more accurate duration matching.

Few actuaries examine the costs of asset/liability matching. Fewer still seek to balance these costs against the benefits of a more stable operating income and the reduced risk of insolvency. See below for further discussion of this.

Richard Woll has shown how to estimate loss reserve payout patterns by line of business from Annual Statement data.[6] In brief, loss reserve payout patterns for the Schedule P lines of business can be determined for 10 years. Loss payouts after 10 years may be estimated by an exponential decay model.[7] Loss reserve durations are then determined by discounting the nominal loss payments at an appropriate investment rate.

We illustrate the traditional calculation of liability "durations" for General Liability loss reserves. Part 2 of Schedule P shows historical loss payout patterns by line of business. Using prior experience to forecast expected future payout patterns for each accident year (using a paid loss development analysis), Richard Woll calculated the percentages shown in Figure 4.[8]

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[5] See, for example, Peter D. Noris, "Asset/Liability Management Strategies for Property & Casualty Companies," Morgan Stanley, May 1985.

[6] Richard G. Woll, "Insurance Profits: Keeping Score," in Financial Analysis of Insurance Companies, CAS 1987 Discussion Paper Program, particularly pages 505-514 and 522-523.

[7] The exponential decay assumption simplifies the mathematics, but it is not crucial for the estimates of reserve duration. Any reasonable model, such as simply dividing the remaining loss payouts equally over the next five years, produces approximately the same durations. The exponential decay model is described by Charles A. McClenahan, "A Mathematical Model for Loss Reserve Analysis," Proceedings of the Casualty Actuarial Society, LXII (1975) pp. 134-153.

[8] Richard Woll, op. cit., p. 511 (Exhibit IX, Page 1). Woll's exhibit shows cumulative payments. The numbers in Figure 4 are the first differences of Woll's percentages.

Figure 4: General Liability
Loss Reserve Payout Pattern

Accident Year	Development Year 1	2	3	4	5	6	7	8	9	10	11+
1983	16.1%	15.3%	14.6%	11.9%	9.2%	7.0%	5.3%	4.2%	3.3%	2.6%	10.5%
1984	16.4	16.3	14.3	11.7	9.1	6.8	5.2	4.1	3.3	2.5	10.3
1985	17.3	16.1	14.2	11.6	8.9	6.8	5.1	4.1	3.2	2.5	10.2

Notes: Since these are loss reserve payout patterns, the first development year is the first calendar year subsequent to the accident year. For example, development year #1 for accident year 1985 is calendar year 1986.

The numbers shown are the percentages of required reserves for each accident year that are paid in each development year. For instance, 16.1% of required General Liability reserves for accident year 1983 were paid in 1984; 15.3% were paid in 1985; and so forth. The percentages for calendar years 1986 and onward are estimates based on historical loss payout patterns.

The timing of loss payments within each calendar year, as well as the pattern of payments after the tenth calendar year, do not have a major effect on the "duration." For simplicity, we assume that all loss payments are made at mid-year, and that loss reserves still held after 10 years are paid out evenly over the subsequent five years.[9] For accident year 1983, 10.5% of required loss reserves are still held after 10 years. We therefore assume a payout pattern of 2.1% for years 11 through 15.

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[9] The exponential decay model used by Richard Woll is more accurate. However, the loss payout patterns are then more difficult to calculate. The simplified method in the text is sufficient for the heuristic purposes of this paper.

Similarly, the average General Liability loss payment is not made at the midpoint of the policy year or of the succeeding years. Rather, the average payment date is close to the end of the policy term during the initial year, and it gradually recedes towards the midpoint of the policy term as the development years continue. This phenomenon has little effect on the arguments in the text, and it unduly complicates the mathematics.

In 1983 and 1984, new issues of Moody's grade Aaa corporate bonds were yielding between 11% and 13% per annum. Since such bonds form a large percentage of insurers' investable assets, we use a 12% interest rate to calculate the reserve "duration."[10]

The General Liability 1983 loss reserve "duration" is therefore

$$\frac{16.1*0.5*(1/1.12)^{0.5} + 15.3*1.5*(1/1.12)^{1.5} + \ldots + 2.1*14.5*(1/1.12)^{14.5}}{16.1 * (1/1.12)^{0.5} + 15.3 * (1/1.12)^{1.5} + \ldots + 2.1 * (1/1.12)^{14.5}}$$

or 3.2 years. This figure is substantially the same as that derived by other actuaries and analysts for liability reserve "durations."[11]

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[10] Richard Woll uses a 5.9% interest rate for 1983, based on short term Treasury bill rates. The risk free rate is appropriate for discounting loss reserves, thereby separating insurance and investment returns. For duration matching, however, we must use the same interest rate for the liabilities as we use for new investable assets.

[11] For 1983, Richard Woll calculated the General Liability loss reserve duration as 3.2 years, the overall Schedule P loss reserve duration as 2.1 years, and the all lines loss reserve duration as 1.95 years; see Woll, op. cit., p. 523. Peter Noris obtained a 1983 liability duration of 2.5 years for an insurance portfolio of Automobile Liability, Automobile Physical Damage, Workers' Compensation, Multi-Peril, and General Liability, weighted in the same proportions as the overall industry portfolio (see Noris, op. cit., pp. 8 and 26). This is longer than Woll's 2.1 years for all Schedule P lines combined, since Noris assumes slower payout patterns. For instance, his General Liability payout pattern assumes that only 32% of losses are paid in the first three years. Woll estimates that 46% of initial General Liability loss reserves are paid within the first three subsequent years.

This discrepancy results from the type of loss payout pattern used by each analyst. Noris uses the loss payout pattern for losses incurred during a specific accident year. In agreement with Noris, Woll estimates that 31% of General Liability losses are paid in the first three years. But for liability durations, Woll uses the payout pattern for loss reserves, not for incurred losses.

The two types of loss payment patterns are quite different. Many losses are paid during the year of occurrence, and do not appear as reserve liabilities on the year end accounting statement. Those losses that remain outstanding as of December 31 as generally the slower settling ones. Thus, the loss reserve payout pattern is usually slower than the incurred loss payout pattern. Thus, The apparent conclusion is that to duration match a General Liability liability portfolio, you should invest in medium term bonds with an average duration of 3.2 years.

Interest Rate Changes:

This conclusion is misleading. Asset/liability matching mitigates the risk of interest rate changes. But the procedure outlined above does not model the true effects of interest rate changes on insurance loss payments.

Richard Woll shows an average payment date for all lines combined of 1.72 years for incurred losses and 2.33 years for loss reserves (see Woll, op. cit., p. 510, Table XIV).

For General Liability and Medical Malpractice, Woll shows the opposite relationship: significantly longer average payment dates for incurred losses than for loss reserves. Perhaps this is due to differences in the loss dates in the two calculations: loss reserves include losses from older accident years, while incurred losses are from the current accident year. The implication would be that in the past, General Liability and Medical Malpractice claims were settled more quickly, but average payment dates have lengthened in recent years. However, Woll's Exhibit VIII on page 506 does not support this hypothesis: average payment dates have remained constant for these two lines of business between 1977 and 1985.

For further discussion of this topic, see Woll, op. cit., p. 513.

The proper payout pattern depends on the type of matching. If one matches assets held as of December 31 with liability obligations as of the same date, then one should use the loss reserve payout pattern. If one matches assets purchased with liabilities incurred, then one should use the loss incurred payout pattern.

The discount rates used by Noris and Woll do not differ much, and do not account for the duration discrepancy. Noris uses the municipal bond rate to estimate an after-tax return. Woll uses an after-tax short-term Treasury bill rate to estimate the risk free return. These two rates are close enough that their difference has little effect on the liability "duration."

Suppose an insurer has a General Liability loss reserve that will be paid 5 years hence for $100,000. Further, suppose that inflation is 5% a year, but both medium term corporate bonds and General Liability loss cost trends are several percentage points above the general inflation rate. For simplicity, assume both are +10% per annum.[12]

To fund this liability, the insurer invests $62,092 in five year zero-coupon bonds that yield 10% per annum.[13] The bonds mature in five years for $100,000 - just enough to pay the liability.

What happens when interest rates change? Suppose inflation accelerates to 10% per annum shortly after the reserve is set up and the zero-coupon bond is purchased, and it remains at 10% for the next five years. Bond yields and loss costs follow inflation, with each increasing to 15% per annum.

The expected ultimate loss is now $125,000 ($= \$100,000 * (1.15/1.10)^5$). But the bond still matures for $100,000 in five years. Duration matching has not helped the insurer mitigate the risk of interest rate changes.

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[12] The assumption that the bond yield equals the loss cost trend is made for simplicity only. The three assumptions that underlie the argument are:

(1) Inflation affects General Liability loss payments through the settlement date.
(2) General Liability loss cost trends vary with inflation.
(3) Bond yields vary with inflation.

[13] The term of a zero-coupon bond equals its duration. For the illustrative bonds in the text, both the duration and the term are five years.

Inflation Sensitive Cash Flows:

The mistake was in estimating the liability loss reserve duration, not in duration matching theory. Cash flows from fixed income securities and traditional life insurance products are expressed in nominal terms. Asset/liability matching either (a) balances insurance and investment nominal cash flows or (b) balances the insurance cash flows with changes in investment cash flows plus capital gains and losses.

The cash flows from General Liability losses, however, are inflation sensitive. If liability losses are sensitive to inflation through the settlement date (with no lag between inflation and its effects on losses) then the reserve is equivalent to an asset with a duration of zero years. That is, to eliminate the influence of interest rate changes on net worth, you should invest either in short term securities (e.g., commercial paper and Treasury Bills) or in securities that are also inflation sensitive (e.g., common stocks and real estate).

In practice, most reserves are not fully inflation sensitive through the settlement date. Workers' Compensation indemnity payments are largely fixed at the accident date. Automobile Bodily Injury wage loss and medical bills may be determined soon after the accident - often a year or two before the settlement date. Nevertheless, "general damages," which form the bulk of insurance payments in General Liability, Products Liability, Medical Malpractice, Commercial Multi-Peril liability coverages, and Automobile Bodily Injury, are inflation sensitive through the settlement date.[14]

Inflation is increasingly important for insurance liability losses through the settlement date. When the losses are not easily quantified, such as "pain and suffering" awards, juries are influenced by the value of money at the settlement date, not at the accident date. Medical bills depend on the time of treatment, which falls between the accident and settlement dates. Even in disability cases, as long as the reparations are decided by a jury instead of by statute, the plaintiff's attorneys usually incorporate the effects of inflation and expected earnings changes in the demand for damages. In other words, most liability reserves are inflation sensitive; they are equivalent to short duration assets. Property reserves, on the other hand, are not inflation sensitive. Since they are paid out quickly, however, they have equally short durations.[15]

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[14] For a more complete discussion of the timing of inflation on insurance losses, see Robert P. Butsic, "The Effect of Inflation on Losses and Premiums for Property-Liability Insurers," Inflation Implications for Property-Casualty Insurance, 1981 Casualty Actuarial Society Discussion Paper Program, p. 51.

When the insurance payments indemnify economic losses, such as work disability and medical bills in automobile personal injury claims, the "loss date," or "treatment date," should replace the accident date in Butsic's model. If the loss date is coterminous with the accident date, this revision has only a minor effect. Sometimes, however, the "loss date" or "treatment date" is closer to the payment or settlement date than to the accident date. For instance, suppose a motor vehicle accident victim in a no-fault compensation state suffers an injury requiring extended medical treatment. The medical bills may continue for years after the accident, and the insurer will reimburse the victim soon after the treatment.

Butsic notes that both interest rates and loss cost trends vary closely with inflation. Butsic's reviewer takes him to task for this, claiming that interest rates and inflation are not as well correlated as Butsic implies. In the short term, this is correct, since numerous factors besides inflation affect interest rates. Over the long term, however, interest rates do vary closely with inflation. One may infer, as both this paper and Butsic's paper do, that expected interest rates are directly correlated with expected inflation.

[15] Steven D'Arcy makes the same argument in his excellent review of Ronald Ferguson's "Duration" in the Proceedings of the Casualty Actuarial Society,

Short-term commercial paper has a duration similar to that of General Liability loss reserves. If interest rates increase, the ultimate expected loss payment increases. Reinvestment returns from the commercial paper's maturity payments increase similarly. Since the assets are short term, there is little change in market price. In other words, the assets (commercial paper) and liabilities (GL losses) change in the same direction. If loss cost trends and commercial paper yields change by approximately the same amount, the magnitudes of the asset and liability changes are also equal.[16]

This is by no means a recommendation for investments in commercial paper. Most insurers buy long-term bonds. Short-term commercial paper provides lower yields and incurs higher transaction costs than do other fixed income securities. These issues are discussed in the following sections. We first turn, however, to duration estimates for equity securities.

LXXI (1984) pp. 8-25. Peter Noris also notes the inflation sensitivity of insurance losses, but he believes that conservative reserving obviates this problem; see Noris, op. cit., pp. 43-45. However, conservative reserving and asset/liability matching are different types of solutions to the general valuation problem. The former says, "Make reserves sufficiently redundant so that they will be adequate even under adverse conditions." The latter says, "Keep reserves accurate, but choose matching assets so that changes in conditions affect the two sides equally."

When conservative reserving is used to guard against non-financial uncertainties, it may be used even with asset/liability matching. For example, American courts have interpreted the pollution exclusion in General Liability policies in diverse ways. The insurer may set up a large bulk reserve for such "extra-contractual" liabilities that the courts discern in the policy and impose on the carrier. This is unrelated to the asset/liability matching problem.

[16] The similarity in magnitude assumes only that the yields change by the the same amount, not that they be equal. General Liability loss cost trends in the 1970's and 1980's have exceeded commercial paper yields. If inflation accelerates, however, the changes in trends and yields may be about equal.

III. EQUITY DURATIONS

The previous section distinguished between nominal and inflation sensitive loss payments. Asset durations are similar. Securities with fixed coupons and maturity repayments are like nominal life insurance and annuity products. Macaulay durations are weighted averages of payment dates. Securities whose annual payments and "maturity" values vary directly with inflation rates and interest rates, such as common stocks, are like casualty insurance liabilities. Macaulay durations are misleading for asset/liability matching.

This is the crux of this section. Asset and liability durations help quantify the effects of interest rate changes on market values. In general, the change in market value is proportional to the duration times the change in the interest rate. Long-term bonds are more sensitive to interest rate changes than commercial paper and Treasury bills are.

Figure 5 illustrates this phenomenon. Consider two zero coupon bonds, with five and ten year terms, respectively. Each has a par value of \$1,000, and each pays 10% per annum. The issue prices, therefore, are $\$1{,}000 * (1/1.10)^5 = \$621$ and $\$1{,}000 * (1/10)^{10} = \$386$, respectively.

Suppose that new money interest rates change by one percentage point the day after issue. Figure 5 shows the new market prices of these bonds.

Figure 5:
Effects of interest rate changes on market values

Market value:

Zero-coupon bonds	at 10%	at 9%	Change $	Change %	at 10%	at 11%	Change $	Change %
5 year term:	$621	$650	$29	+4.7%	$621	$593	$28	-4.5%
10 year term:	386	422	36	+9.3	386	352	34	-8.8

A zero coupon bond's duration equals its term. Thus, the two durations are 5 and 10 years, respectively. Accordingly, the change in market price for the ten year bond is double that for the five year bond when new money interest rates change slightly.[17]

Common Stocks:

How should the duration of common stocks be measured? Stated differently,

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[17] Mathematically, the change in price equals the negative of the Macaulay duration times the market price times the change in the interest rate, or

Change in Price = -1 * Duration * Price * Change in Interest Rate.

For a decline in interest rates from 10% to 9% per annum, the changes in market price should be

Ten year bond: -1 * 10 * $386 * 0.01 = $38.60
Five year bond: -1 * 5 * $621 * 0.01 = $31.05

These figures differ from the actual market price changes because the change in the interest rate is not "infinitesimally" small. For a more extensive treatment of this subject, see G. O. Bierwag, George G. Kaufman, and Alden Toevs, "Duration: Its Development and Use in Bond Portfolio Management," Financial Analysts Journal, July-August 1983, especially pp. 17-18.

"What definition of common stock duration helps quantify the effects of interest rate changes on market values?"

The traditional measurement of common stock duration uses the "dividend discount model" of equity valuation. This model views a common stock as a perpetual bond that pays dividends for an infinite term. If dividends are assumed to grow at G% per annum, and values are discounted at K% per annum, then the present value of the stock's dividends is

(current dividend) * (1 + G) / (K - G).[18]

The duration of a fixed income security equals the negative of the derivative of the natural logarithm of its present value with respect to the discount rate.[19] Using this equation for common stocks, the duration equals

$$- \frac{d\,\{\ln\,(\text{current dividend} * (1 + G)) - \ln\,(K - G)\}}{d\,(K)} = \frac{1}{(K - G)}$$

In the mid-1980's dividends grew at about 6%. A discount rate of 10% implies

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[18] The sum of the discounted dividend payments is

$$\sum_{t=1}^{\infty} \frac{\text{current dividend} * (1 + G)^t}{(1 + K)^t}$$

where "t" is the number of years since the purchase date. This reduces to the formula in the text.

For further exposition, see J. Fred Weston and Thomas E. Copeland, Managerial Finance, eighth edition (Chicago: The Dryden Press, 1986), pp. 609-10. In the formula, "K" represents the cost of capital and "G" represents the dividend growth rate.

[19] See, for example, Martin L. Leibowitz, et al., "A Total Differential Approach to Equity Duration," (New York: Salomon Brothers, Inc., n.d.), p. 3. Leibowitz similarly concludes that traditional measures of equity duration give meaninglessly high figures.

a duration of 25 years for the average common stock. This exceeds the duration of even long-term corporate bonds.

Market Price Changes:

What happens to common stock prices when interest rates change? A long duration implies that stock prices will shift strongly in the opposite direction of the change. This is true for long term bonds, but it is not true for common stocks.

Interest rate and inflation rate changes affect common stock prices in several ways.

1. Value of the firm: In theory, the real value of the firm's major assets should not be affected by inflation. If inflation and interest rates accelerate, the nominal value of the firm should increase accordingly, so that its inflation-adjusted value remains constant.

2. Supply and Demand: In practice, the value of a firm depends on its revenues and costs. When inflation and interest rates accelerate, supply costs increase, but demand may or may not. If inflation is "demand-pull," there is excess demand. If inflation is "supply-push," demand may be weak. Moreover, rising interest rates encourage households to save, not consume, further reducing demand.

In sum, accelerating inflation and interest rates increase costs but may not increase demand. In such cases, the values of the firm and of its common stock will decline.

3. Investment strategy: When interest rates rise, investors often shift their holdings from common stocks to long-term bonds, to "lock in" the high rates. The lessened demand for common stocks reduces their market prices.

The first effect is long-term; the next two are short-term. In other words, when inflation and interest rates rise unexpectedly, common stock prices decline at first, but rise later.

We quantify this phenomenon by correlating inflation rates with (a) common stock capital appreciation and (b) long term government bonds capital appreciation. The correlations below used 1962-81 annual returns.[20]

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[20] Annual and monthly figures are from Roger C. Ibbotson and Rex A. Sinquefield, Stocks, Bonds, Bills and Inflation: The Past and the Future (Charlottesville, Virginia: The Financial Analysts Research Foundation, 1982). Ibbotson and Sinquefield do not provide a long-term corporate bond capital appreciation series.

Ibbotson and Sinquefeld's series begin at 1926. The 1929 depression, as well as the post World War II economic prosperity, caused major fluctuations in common stock prices, which overwhelmed the effects of interest rate changes. The 1962-1981 period is more representative of current conditions.

This paper uses the Consumer Price Index (CPI) as a proxy for new money interest rates. An alternative series available from Ibbotson and Sinquefield is the Treasury Bill total return series. However, this lags inflation by up to half a year, and so it is less useful for the correlations.

These series are used only to illustrate the argument in the text. To accurately determine the correlations among new money interest rates, long-term bond prices, and common stock prices, the following adjustments would be needed:

(1) New money interest rates should be measured as coupon rates on newly issued high quality corporate bonds.

The correlation coefficient between the long term government bond capital accumulation series and the consumer price index is -50%. In other words, the market price of long-term bonds varies strongly and inversely with inflation rates (and by implication, with new money interest rates).

If the long term government bond capital accumulation series is lagged one year, the correlation is reduced but is still strongly negative (r = -25%). In other words, there is no "rebound" from the initial decline in market values. Rather, the reduction in the correlation coefficient results from two factors. (1) The market values of bonds move towards their par values as the time to maturity shortens. (2) Newly issued bonds are not affected by past changes in interest rates.

The correlation coefficient between the common stock capital accumulation series and the consumer price index is -19%. In other words, the market price of common stocks varies inversely but weakly with inflation rates.

However, if the common stock capital accumulation series is lagged one year, the correlation turns positive (r = +17%). Presumably, an initial acceleration of inflation hurts most firms, and their equity values decline. After several months, however, firms adjust their costs and prices, so nominal

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(2) Smoothed monthly or quarterly rates should be used.

(3) One year lags should be replaced by lags of differing lengths, depending on the ease with which the firm can pass on cost increases.

(4) Interest rate changes should be examined in conjunction with the absolute values of the interest rates.

See the discussion in the text for elaboration of the third point.

common stock values vary directly with recent inflation rates.

In sum, common stock prices are sensitive to inflation. Common stocks are similar to casualty reserves, in that both track the real value of money.[21]

Why does the traditional duration formula give stocks a 25 year duration? The traditional calculation uses the current dividend growth rate to determine dividend payments in future years. But if inflation and interest rates change, the dividend growth rate will change as well. The change in the growth rate will lag the change in the inflation rate, since firms dislike modifying the dividend rate too frequently. Once a firm changes the dividend rate, though, the new "dividend discount model" valuation of the firm will vary in the same direction as the inflation rate.

The effect of inflation upon common stock prices depends upon the type of firm. For example, a retail store can quickly increase prices when inflation accelerates. Its nominal value should move rapidly in the same direction as new money interest rates. A municipal utility must apply for rate changes to the state regulatory department. Unexpected inflation should be inversely correlated with common stock prices of utilities.[22]

How, then, should a Property/Casualty insurer divide its assets among common

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[21] If inflation affects insurance losses only through the accident date, not through the settlement date, then trends in paid losses also lag economic inflation. It is not clear whether the lag is greater for the overall stock market portfolio or for the industry-wide insurance portfolio. However, neither lag is large enough to affect the conclusions in the text.

[22] Leibowitz, et al., "Total Differential," op. cit., make a similar argument.

stocks, long-term bonds, and short-term bills? Common stocks and short-term bills have a similar relationship to interest rate changes as liability loss reserves do. Long-term bonds have long durations and so expose the insurer to the risk of interest rate changes. Common stocks and long-term bonds provide higher yields than short-term bills do, allowing an investment return more commensurate with liability loss cost trends. Common stocks expose the insurer to "systematic" stock market risks. Short-term bills and long-term bonds protect against this risk. Finally, long-term bonds entail the lowest transaction costs.[23]

The following section examines these investment attributes: expected yields, transaction costs, cash flows, and market risks. Asset/liability matching is important, but it is only <u>one</u> aspect of an insurer's investment strategy.

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[23] Up until the 1970's, institutional investors were not active traders of stocks and bonds in the secondary markets, so transaction costs were low. During the past decade, institutional investor trading has grown markedly, particularly in common stocks.

IV. EXPECTED YIELDS, TRANSACTIONS COSTS, INSURANCE CASH FLOWS, AND RISKS

Asset/liability matching theory tells the Property/Casualty insurer to invest in short-term securities. For example, Noris recommends that the entire loss reserve portfolio be backed by short-term bonds. He notes that "while some investment managers might perceive that shortening the bond portfolio so dramatically could result in a reduction in investment income (particularly in tax-exempt bonds, where there is typically a steep, positively sloped yield curve), this should not be a major concern."[24]

Expected Yields:

On the contrary, this is indeed a major concern. Asset/liability matching deals with speculative risk. A mismatched portfolio may provide either greater or lesser net income than a matched portfolio provides. The investment analyst deals with expected returns. Shortening the duration of the bond portfolio generally reduces the expected investment income.

The yield differences can be great. High quality long-term corporate bonds usually offer 2 to 5 percentage points more than short-term Treasury bills and commercial paper offer. James Tilley matched a Guaranteed Income Contract with an investment portfolio of three types of bonds: 1-year bonds yielding 7.5%, 2-year bonds yielding 7.75%, and 3-year bonds yielding 8%. He concluded

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[24] Noris, op. cit., p. 33.

that "to cover the interest rate risks associated with guaranteeing 7.65 percent for three years and providing annual withdrawal privileges without asset-liquidation (surrender) charges . . . " the insurer can invest only half of the assets in the three year bonds. The matched portfolio's net weighted rate of return is 7.84%. The insurer must forgo fully one third of the interest rate spread between short and medium term bonds.[25]

Transaction Costs:

Transaction costs are equally important. Long-term bonds entail the least expenses, particularly if the bonds are held to maturity. Common stocks involve greater trading expenses as well as a larger investment department to analyze individual equities. Accurate asset/liability matching requires continual monitoring of new money interest rates and rebalancing of the financial portfolio.

Disintermediation:

What risk does asset/liability matching guard against? Answers like "the risk

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[25] James A. Tilley, "The Matching of Assets and Liabilities," Transactions of the Society of Actuaries, XXXII, p. 293. Note also the fourth criticism of conventional immunization theory that Tilley cites: "Immunization theory in its conventional form places rigid constraints on investment operations, leaving investment officers with too little latitude for making policy decisions" (p. 264). Tilley believes, however, that the resolution of this problem is "largely a matter of education."

of interest rate changes" or "the C-3 risk," beg the question: How do interest rate changes affect the Property/Casualty insurer?

Life actuaries answer: "When interest rates decline, investment returns may fall below the guaranteed interest yield in the whole life policy. When interest rates rise, insureds may withdraw funds by means of policy loans (i.e., "disintermediation"), forcing insurers to sell bonds at capital losses. Either way, the insurer loses."

This is misleading. Guaranteed interest rates in whole life policies are so conservative that there is little chance that they will exceed investment returns over the long term. And when new money interest rates rise above the policy loan interest rate, insurers receive investment income above their expected return regardless of the extent of disintermediation. An illustration should make this clear.

Consider a one year annuity certain with a contract loan provision. The annuitant deposits $1,000 with the insurer on January 1. The insurer promises to pay $1,040 on December 31, but it expects investment returns of $50 during the year, for a net profit of $10. The annuitant may withdraw the cash value of the annuity as a loan at any time, subject to 6% interest per annum.

If new money interest rates increase from 5% to 8% on January 2, the annuitant might take a $1,000 contract loan to reinvest the money at the higher rate. Clearly, the insurer would prefer that the annuitant not take the loan, because it would earn $40 (= $1,080 - $1,040). But even with the contract loan, its profit is $20 (= $1,060 - $1,040), exceeding the expected profit of $10.

What about the capital loss on 5% bonds purchased on January 1? The capital loss occurs before the annuitant requests the loan. The disintermediation simply forces realization of the capital loss. Statutory financial statements allow amortization of bonds in good standing, so the unrealized capital loss does not appear on the insurer's income statement. The reduction of statutory net income that results from disintermediation is caused by the vagaries of statutory accounting principles. Determining the economic worth of the insurer requires marking bonds to market. The withdrawal of funds by insureds and annuitants to obtain higher returns from other investments does not have a significant adverse effect on economic worth.[26]

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[26] For participating policies, the issue is more complex. Suppose the premiums on a participating whole life policy assume 2% interest, new money interest rates are 5%, and the policy loan interest rate is 6%. Suppose further that new money interest rates increase to 10% soon after the policy is issued. The insurer intends to return most of the difference between actual and assumed interest returns through policyholder dividends. If more than 4% of the interest rate differential is returned to an insured who has taken a policy loan of the entire cash value, then the insurer has a negative interest rate margin on the policy.

One solution to this problem is to vary the dividend payments by the extent of the policy loan. The full dividend is paid if the policy cash value remains intact, while a lesser dividend is paid to insureds with policy loans. Critics of this practice argue that obtaining a policy loan is a statutorily guaranteed right, no less than the beneficiary's right to receive the face value upon death of the insured. The insured's illness does not affect his policyholder dividends, even though it shortens his expected life and therefore reduces the insurer's mortality margin. So also a loan should not affect policyholder dividends. For further discussion of this, see R. C.

Cash Flows:

For Property/Casualty insurers, the risk is different. When new money interest rates decline, the portfolio investment return exceeds the new money investment return. Liability loss cost trends decline as well, so net operating income increases.

When new money interest rates rise, the portfolio investment return falls below the new money investment return. Liability loss cost trends rise above the expected levels, so net operating income decreases. The magnitude of the difference between portfolio and new money investment returns depends upon the duration of the financial portfolio. The longer the duration of the financial portfolio, the greater the reduction in net operating income as interest rates rise.

Interest rate changes expose the insurer to two risks. The first is the risk of statutory insolvency, if the rise in interest rates depletes the insurer's surplus. The amortization of long-term bonds on statutory financial statements reduces this risk, though it does not eliminate it. After liquid assets and short-term securities are used to pay claims, the insurer must sell long-term bonds and realize the capital losses.

How likely is this to happen? Many Property/Casualty insurers do become

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Winters, "Philosophic Issues in Dividend Distributions," Transactions of the Society of Actuaries XXX, pp. 125-137.

insolvent. The question is "To what degree are insolvencies caused by interest rate changes?" In other words, "What is the probability that interest rates will rise so dramatically that they force an insurer to sell long- term bonds at capital losses and become statutorily insolvent?"

A pension plan funding vehicle can use a segregated account to back its liabilities. Fewer non-vested participants may withdraw from employment than expected, or retirees may live longer than expected. The investment manager may then be forced to sell assets from the segregated account before their maturity dates. The segregated account funds a fixed block of liabilities. It must provide investment cash flows similar to and in the opposite direction of the insurance cash flows.

The Property/Casualty insurer has a single asset account. The insurer holds long-term bonds to maturity, and it uses current premium and investment income to pay claims. Only when the insurer becomes insolvent because of other reasons, such as inadequate pricing or incompetent management, does premium income dry up. In other words, a financial portfolio with an excessively long duration combined with a rise in interest rates may exacerbate an insolvent insurer's negative net worth, but they will rarely cause the insolvency itself.

The investment manager desires high yielding securities, and the risk of interest rate changes is not significant for a stable Property/Casualty insurer. But should the insurer invest in short "duration" common stocks or long duration bonds?

Risks:

This question is not related to asset/liability matching. Each type of security presents its own risks. Common stocks expose the insurer to systematic market risks, such as the market declines in 1975 and 1987.[27]

Long-term bonds, if marked-to-market, expose an insurer to the risk of fluctuating inflation rates. The investment manager must balance these two risks in the financial portfolio.

Conclusion:

In sum, the liability reserves of Property/Casualty insurers are inflation sensitive. They are similar to common stocks, other equity investments, commercial paper, and Treasury bills. Commercial paper and Treasury bills are highly liquid short-term investments, but their expected yields are too low for large carriers. Real estate and similar investments are limited by regulation and are too risky for all but the most experienced investment managers. Common stocks, therefore, are the apparent investment of choice.

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[27] In truth, there was no "market crash" in 1987, because the market returned about 5% over the year. The impression of a crash resulted from the sudden readjustment in October 1987. The 1987 experience differs from a true market collapse in that no economic downturn followed October 1987.

Interest rate changes do not pose a serious risk for stable Property/Casualty insurers. Long-term corporate bonds may entail a duration "mismatch," but they offer higher yields than other fixed income securities offer. The actuary and the investment analyst must be aware of the types and inflation sensitivities of the insurer's assets and liabilities. But asset/liability matching is but one investment concern. The traditional concerns remain paramount: maximizing expected returns, ensuring safety of principal, and balancing the risks of each class of securities.