Financial Pricing Models for Property-Casualty Insurance Products: Implementation and Presentation

Sholom Feldblum, FCAS, FSA, MAAA, and
Neeza Thandi, FCAS, MAAA

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INTRODUCTION

The pricing of the insurance policy in Feldblum and Thandi, [2002], "Modeling the Equity Flows." relies on setting the internal rate of return of the implied equity flows equal to the cost of equity capital. The performance measurement system in Feldblum and Thandi, [2002], "Income Recognition and Performance Measurement," and in Schirmacher and Feldblum, [2002], "Retrospective Analysis," relies on the economic value added in an NPV or an IRR accounting framework.

Insurance practitioners measure their performance by loss ratios and combined ratios. The equity flows and EVA performance measures are not always practical for judging the acceptability of an underwriting submission or for understanding the sensitivity of the policy premium to the pricing assumptions. To speak the language of its users, a pricing model must translate the target return on capital into target loss ratios or target combined ratios.

This is not an issue of education, as if the more sophisticated underwriter speaks of returns on capital and the naive underwriter speaks of loss ratios. Numerous factors affect the return on capital, including the surplus requirements, the investment yield, the reserve valuation rate, and the incidence of federal income taxes. Even a proficient pricing actuary can not judge the acceptability of a complex underwriting submission without the aid of computer software. It would be unrealistic to expect underwriters or sales personnel to judge coverage acceptability based on the implied equity flows alone.

This paper deals with implementation of a return on capital pricing model and with the presentation of pricing indications to insurance practitioners. The pricing model itself is documented in the companion papers in this series.

- Given the pricing assumptions, we show the loss ratio or combined ratio needed to achieve a target return on capital. The target loss ratio or combined ratio may be used as performance goals or plan objectives for underwriting units in the company. In addition, the target loss ratios may be used for actuarial rate filings.
- We show the sensitivity of the target loss ratio or combined ratio to the discretionary pricing assumptions. A keen understanding of this sensitivity is necessary for setting challenging but attainable performance objectives.

PRICING ASSUMPTIONS

There are several types of pricing assumptions discussed in this paper.

- Exogenous facts, such as federal income tax rates, premium tax rates, or state assessments; contractual items, such as agents' commissions; and general expenses items, such as overhead and salaries.
- Line of business data, such as cash flow patterns for premiums, losses, and expenses, and ratios of ALAE and ULAE to losses.
- Discretionary items selected by the company's management.

The discretionary assumptions are constrained by the financial and regulatory environments, but they also rely on business judgment. The pricing model uses four discretionary assumptions:

- the target return on capital
- the benchmark investment yield
- the surplus requirements
- the reserve valuation rate

Understanding the relationships between the pricing indications and these discretionary assumptions is essential for managing the underwriting operations of an insurer.

INSURANCE PRICING AND RATE FILINGS

Insurance rates are regulated in most states. Actuarial ratemaking varies by insurer, though the work can often be divided into two parts:

1. *Pricing:* The pricing model determines the target loss ratios or combined ratios, based on the line of business characteristics and the pricing assumptions.
2. *Rate Approval:* The statutory rate filing adjusts the premium rates to attain the targeted loss ratio during the coming policy period.[1]

The selection of the target combined ratio is sometimes expressed as the selection of the target underwriting profit margin, since the profit margin + the combined ratio = 100%.

Some states have formal procedures for selecting the target underwriting profit margin. Since 1982, Massachusetts has selected the target underwriting profit margin by a Myers/Cohn discounted cash flow analysis. Other states permit more leeway in selecting the underwriting profit margin.

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[1] Rate filing procedures are documented in the casualty actuarial literature; they are not discussed here. The standard reference for workers' compensation ratemaking is Feldblum [1992: WCR].

TARGET LOSS RATIOS

The determination of the indicated premium proceeds as follows.

BASE

A base dollar amount, such as $1,000, of losses plus ALAE is selected. The indication of the pricing model is the target loss ratio or combined ratio, any base dollar amount may be used.

LINE OF BUSINESS EXPENSES

- ULAE is added as a percentage loading onto losses plus ALAE, based on past company experience.
- Acquisition costs are loaded as a percentage of premiums, based either on contract terms (agents' commissions) or statute (premium taxes).
- General expenses are loaded as a percentage of premiums based on past experience.

CASH FLOW PATTERNS

Cash flow patterns are based on the line of business, the jurisdiction, and the policy characteristics. In workers' compensation, for instance, the loss payment pattern depends on the state compensation system and the size of the policy deductible. The premium collection pattern depends on the type of policy, such as first dollar prospectively priced policy versus a paid loss retrospectively rated policy.

DISCRETIONARY PRICING ASSUMPTIONS

The discretionary pricing assumptions are chosen by management. In most companies, these pricing assumptions are based on actuarial, financial, or investment department recommendations.

The pricing model solves for the policy premium that provides the target rate of return on the implied equity flows.

- The dollar amount of ultimate losses divided by the indicated premium is the target loss ratio.
- The target loss ratio plus the expense ratio is the target combined ratio.

PRICING RESULTS

Exhibit 1 illustrates the management output generated by the pricing model. This exhibit, like the sensitivity exhibits discussed further below, is geared to company management; the

exhibits showing the derivation of the indicated premium and loss ratios are documented in Appendix B of Feldblum and Thandi, [2002], "Modeling the Equity Flows."

The exhibit has five sections:

1. Underwriting Assumptions
2. Finance Assumptions
3. Risk (Surplus) Assumptions
4. Pricing Results
5. Profitability

The exhibit shows simulated results for a first-dollar workers compensation block of business.[2]

SECTION I: UNDERWRITING ASSUMPTIONS

Subsection "A: Policy Costs" shows the ultimate loss plus ALAE of $1,000. The $1,000 loss is an arbitrary reference figure; all other costs are direct or indirect functions of the loss cost.

ULAE is loaded onto loss plus ALAE by a factor of 7.2% based on past company experience. It is shown separately from loss plus ALAE since ULAE has a faster payout pattern.

Acquisition and general expenses are treated as a percentage of premium (25.6%). Expected policyholder dividends are loaded as an additional expense item (5.7%). Since we are solving for the aggregate block of business target combined ratio, not for an individual policy premium, expense flattening procedures and premium discount factors by size of policy are not necessary.

Subsection "B: Cash Flow Patterns" shows the cash flow assumptions.

- The actual model uses the full cash flow patterns for losses and premiums.
- The exhibit shows the ratio of the discounted amount to the undiscounted amount as a proxy for the cash flow pattern. This ratio is used to convert undiscounted amounts to discounted amounts.

Workers' compensation is a long-tailed line of business; discounted losses are only three quarters of undiscounted losses. For many large account workers' compensation business, premiums are paid in installments.[3]

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[2] "First dollar" means there is no deductible on the policy.

[3] For workers' compensation, insurers may book the premium as it is billed, thereby delaying the incidence of state premium taxes and slightly reducing the capital requirements for the policy. The company being modeled here books all premium at the policy effective date, in compliance with IRS procedures. See

SUMMARY OF ASSUMPTIONS AND RESULTS FOR WORKERS' COMPENSATION

Fully Insured Policies

I. UNDERWRITING ASSUMPTIONS

A) Policy Costs	
Expense Ratio (as % WP)	25.6%
Dividend Ratio (as % WP)	5.7%
ULAE Ratio (as % of Loss&ALAE)	7.2%
Ultimate Loss & ALAE	1,000
B) Cash Flow Patterns	
Disc Loss&ALAE to Undisc	73.0%
Duration of Losses (in yrs)	4.3
Disc Premium to Undisc	95.3%
C) Average Effective Date	0.5
D) Level of Reserve Adequacy	
Held to Nominal Reserves	100.0%

II. FINANCE ASSUMPTIONS

A) Investment Rate of Return	
Assets Backing Liablities & Surplus	8.0%
B) Federal Income Taxes	
Marginal Income Tax Rate	35.0%
Tax on Investment Returns	35.0%
C) Target Return on Capital	
Post-Tax Return	**12.0%**

III. RISK (SURPLUS) ASSUMPTIONS

Reserve Leverage Ratio	0.0%
Premium Leverage Ratio	43.7%

IV. PRICING RESULTS

A) Premium		
Nominal Premium	1,374	
Discounted Premium	1,309	
B) Summary of Costs		
Disc Loss & LAE	784	
Disc Expense (incl PHR Dividends)	416	
Disc Taxes	67	
	1,267	
	Nominal	Discounted
C) Ratios	(% of Nominal Prem)	(% of Disc Prem)
Loss & ALAE Ratio	72.8%	55.8%
ULAE Ratio	5.2%	4.1%
Expense Ratio (incl PHR Dividends)	31.3%	31.8%
Combined Ratio	**109.2%**	91.6%

V. PROFITABILITY

A) Equity Charge	Nominal	Discounted
	107.48	42.56
B) IRR on Equity Flows		
Post-Tax IRR	**12.0%**	

Subsection "C: Average Effective Date," uses a mid-year (July 1) assumed effective date as a proxy for an even distribution of effective dates throughout the year. The effective date is relevant for pricing because the loss reserve discount factors applicable to the book of business depend on the accident year of the losses.

Subsection "D: Level of Reserve Adequacy" shows the expected loss reserve valuation rate. The 0% valuation rate implies that reserves will be carried at full value. For the effects of the reserve valuation rate on the indicated premium, see Feldblum and Thandi [2002], "Reserve Valuation Rates" and Feldblum and Thandi [2002] "Federal Income Taxes and the Cost of Holding Capital."

SECTION II: FINANCE ASSUMPTIONS

Subsection "A: Investment Rate of Return" is the pre-tax equivalent benchmark investment yield, expressed with semi-annual compounding.[4] The benchmark yield is based on the company's expected investment portfolio during the life of this block of business.

Some pricing actuaries use different expected investment yields on assets backing loss reserves and on assets backing surplus funds.

> *Illustration:* One might use an investment grade bond yield for assets backing loss reserves and a common stock yield for assets backing surplus.

The exhibits in this paper make no assumption about proper investment strategy for property-casualty insurance companies, and they use a single yield on all investable assets.

The benchmark investment yield is a discretionary assumption. For long-tailed lines of business, small changes in the investment yield assumption have relatively large effects on the target loss ratios; see the sensitivity exhibits below.

Subsection "B: Federal Income Taxes" shows the assumed marginal tax rate on underwriting income (35%) and the average tax rate on investment income (35%). In some circumstances, it may be proper to consider the effects of the alternative minimum income tax and the tax exemption of certain investment income. Because of the proration provision in the 1986 Tax Reform Act, few property-casualty insurance companies invest heavily in municipal bonds.

Feldblum [2002: SchP] for full explanation of the statutory and tax premium recognition requirements.

[4] The 7.3% yield in the exhibit is equivalent to a $1.0365^2 - 1 = 7.43\%$ effective annual yield. The investment yield on municipal bonds is converted to a pre-tax equivalent yield so that the 35% marginal tax rate may be applied to all investment income. The proration provision of the 1986 Tax Reform Act changed the effective tax rate paid by insurance companies on municipal bond income from 0% to 5.25%. A Z% municipal bond yield is converted to a $Z\% \times (1 - 5.25\%) / (1 - 35\%)$ pre-tax equivalent yield.

Subsection "C: Target Return on Capital," shows the target return on capital used as the hurdle rate for the NPV calculations and as the discount rate for the EVA calculations. In general, the target return on capital is the cost of equity capital for the company. The company may vary the target return on capital with the fluctuations of the insurance underwriting cycle, marketplace competition, regulatory prescriptions, or long term growth strategies. See the sensitivity exhibits below for the effects of this pricing parameter on the target loss ratio.

SECTION III. RISK (SURPLUS) ASSUMPTIONS

The pricing model derives the indicated premium by examining the return on invested capital. The invested capital is embedded in statutory reserves and in policyholders' surplus.

- The amount of capital embedded in reserves depends the loss payment pattern and the reserve valuation rate. This embedded capital is greatest for full value loss reserves in the long-tailed lines of business. In some instances, companies may hold less than full value loss reserves, particularly if full value loss reserves would make the necessary premiums uncompetitive. The pricing model determines the indicated premiums at any given reserve valuation rate (see Feldblum and Thandi [2002] "Reserve Valuation Rate."
- A minimum level of surplus is mandated by risk-based capital requirements. Most companies hold surplus equal to at least two times the minimum risk-based capital requirements.

The capital held in surplus is subject to management views on optimal capital structure. The allocation of this capital to line of business may be done in a variety of ways. The figures in the exhibit are based on three assumptions:[5]

a. Total company surplus is set at 200% of NAIC risk-based capital requirements, based on the average RBC ratios for companies receiving A ratings from A. M. Best's.
b. The allocation of this surplus by line of business is based on a risk analysis that equates the expected policyholder deficit ratio across lines.
c. Capital requirements are tied to premium writings, not to held reserves, to provide greater incentives for the EVA performance measurement system.

Surplus assumptions are widely debated; there is no consensus in the actuarial community. The assumptions in the pricing model should reflect the surplus carried by the company to support its insurance operations.

SECTION IV: PRICING RESULTS

Actuarial pricing has three distinct meanings.

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[5] See Feldblum and Thandi [2002] "Surplus Allocation" for the rationale of each assumption.

- *Rate Change:* The traditional loss ratio ratemaking procedure determines the required rate change to bring premiums to an adequate level for the future policy period.
- *Pure Premium:* The traditional pure premium ratemaking procedure determines the manual premium rate per unit of exposure.
- *Financial Pricing:* The financial pricing model determines the underwriting profit margin needed to achieve a given financial target, such as a target internal rate of return.

We deal here with financial pricing; we are not determining rate level changes or pure premiums. The output of the financial pricing model is the target underwriting profit margin.

We convert the target underwriting profit margin into two other target ratios that are commonly used by underwriters and actuaries: the target combined ratio and the target loss ratio. The target combined ratio is the complement of the target underwriting profit margin. The target loss ratio is the target combined ratio minus the expense ratio.

> *Illustration:* If the target underwriting profit margin is –6.3%, and the expense ratio is 32.8%, the target combined ratio is 1 – (–6.3%) = 106.3%, and the target loss ratio is 106.3% – 32.8% = 73.5%.

The pricing model output shows the target loss ratio and combined ratio. It also shows several other summary figures, so that users more readily understand the costs of the policy.

Section IV shows nominal and discounted amounts of premiums, losses, and expenses. The nominal amounts are used to determine the target loss ratios and combined ratio. The discounted amounts show the relative sizes of the cost components of the premium. The discount rate is the benchmark investment yield, not the target return on capital.

Subsection "A: Premium" shows the nominal premium amount ($1,374) that provides an internal rate of return equal to the target return on capital of 12%, based on the implied equity flow pattern. This premium provides an net present value of zero at a hurdle rate equal to the target return on capital.

The discounted premium is based on the assumed premium collection pattern: 95.3% × $1,374 = $1,309.

Subsection "B: Summary of Costs" shows the present value of losses, expenses, and taxes at the benchmark investment yield.

- For ultimate losses plus ALAE of $1,000, the discounted amount is $730 (see section 1 of this exhibit).
- The ultimate ULAE is 7.2% × $1000 = $72. The ULAE discount factor is 75.0%, giving a discounted amount of $54. (The ULAE discount factor is not shown on the exhibit.)
- Total discounted losses plus LAE equal $730 + $54 = $784.

- Undiscounted expenses plus policyholder dividends are (25.6% + 5.7%) x $1,374 = $430.06. Most expenses are paid rapidly, and the discounted amount is $416.

The total discounted costs, consisting of losses, expenses, and taxes, is $1,267. The remaining $42.56 in the discounted premium of $1,309 is the net profit margin that covers the cost of holding capital.[6]

Subsection "C: Ratios" show the target loss ratio and combined ratio on both a nominal and discounted basis.

The target loss and ALAE ratio on a nominal basis equals 1000 / 1374 = 72.8%. The target ratio on a discounted basis equals the discounted losses and ALAE divided by the discount premium (not the nominal premium): $730 / $1309 = 55.8%.

The 72.8% target loss ratio transforms the return on capital indications to the more common industry benchmark. The sensitivity analyses below show the effects of the discretionary assumptions on the target loss ratio.

The ULAE ratio is converted from a percentage of losses to a percentage of premiums: 7.2% x 1000 / 1384 = 5.2%. Other expenses are taken from section 1 of the exhibit. The combined ratio is the sum of the loss plus ALAE ratio, the ULAE ratio, and the expense ratio.

INDUSTRY COMPARISON

The 109.2% target combined ratio is appropriate for a participating block of business issued by a mutual insurance company. The equivalent target combined ratio for non participating business issued by a stock insurance company is 109.3% / (1 – 5.7%) = 115.9%.

The company modeled in this exhibit is a large workers' compensation writer with an efficient distribution system, leading to the low 25.6% expense ratio. Many workers' compensation insurers have expense plus dividend ratios of 35% to 40%, giving target combined ratios of about 105% to 110%.

The discretionary assumptions used in this exhibit, such as the 12% cost of equity capital and the 7.3% benchmark investment yield, reflect industry norms. Actual premium to surplus ratios for workers' compensation carriers are about 1 to 1, necessitating more equityholder provided capital than the 43.7% surplus assumption in the exhibit. The use of a 1 to 1 premium to surplus ratio and industry average expense ratios would lead to a target combined ratio of about 100%. We examine the implications for industry profitability at the end of this paper.

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[6] Much of the analysis in the latter half of this chapter deals with the gross (pre-tax) profit margin. The federal income taxes consume 60%-80% of the gross profit margin on long-tailed lines of business. Careful analysis of tax implication is critical to optimal policy pricing.

SECTION V: PROFITABILITY

Subsection "A: Equity Charge" shows the real profit margin in the indicated premium rates. The nominal underwriting profit margin is the undiscounted premiums minus losses and expenses, or –9.2% in this exhibit. This margin has no financial meaning, since it uses undiscounted figures and it takes no account of federal income taxes.

The present value of the policyholder premium ($1,309) covers three types of costs. (The numbers in parentheses are the values in this illustration.)

- The present value of the expected losses and expenses ($1,200).
- The present value of the expected federal income taxes ($67).
- The present value of the cost of holding capital ($42).

We differentiate between the gross profit margin and the net profit margin.

- The gross profit margin ($109) is the present value of the policyholder premium minus the present value of the expected losses, expenses, and policyholder dividends.
- The net profit margin ($42) is the gross profit margin minus the present value of the expected federal income taxes.

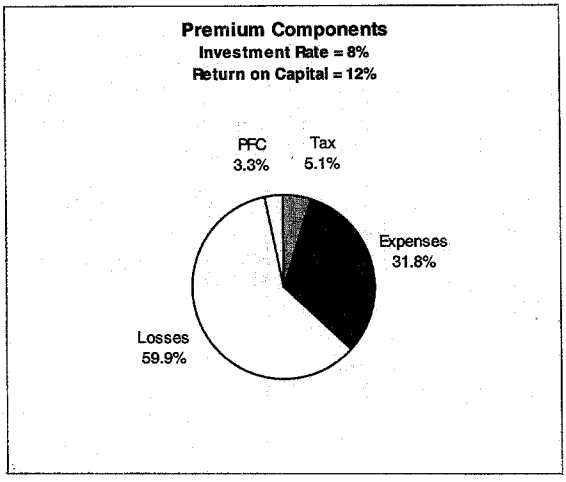
The federal income tax liability depends on the cost of holding capital, not the expected losses and expenses. If the policy premium just covered the expected losses and expenses and contained no margin for profit, and if there were no need for capital to support the insurance operations, the expected federal income tax liability would be zero. The discounted losses and expenses would just offset the premium, giving a zero profit in the first year and no tax liability. In subsequent years, the unwinding (amortization) of the interest discount in the tax-basis reserves would just offset the investment income on the assets supporting the reserves, leading to zero tax-basis profits and no tax liability.

In practice, capital is needed to support the insurance operations. Part of this capital is embedded in the undiscounted loss reserves and part of this capital is held as surplus. The capital is provided by the owners of the insurance enterprise, who are termed equityholders in this paper.

Equityholders demand the target return on capital for their funds, but the insurer invests the money at the benchmark investment yield. The policyholders make up the difference. This is the present value of the cost of holding capital, also termed the equity charge in this exhibit.

These funds are taxed twice at the corporate level: once as underwriting income when the premium is paid and once as investment income when the capital funds are invested. After being paid to the equityholders, the net income is taxed a third time at the personal level.

The net (discounted) profit margin, called the discounted equity charge in the exhiibit, equals the discounted premium minus the discounted losses, expenses, and taxes: $1,309 – $1,267



= $43 ($42.56). The exhibit also shows a nominal equity charge, which uses the undiscounted premium minus the discounted losses, expenses, and taxes. Some users of the pricing model are more comfortable with the nominal equity charge, though it has no financial meaning.

The effective tax rate about 60% is valid when reserves are held at full value. When reserves implicitly discounted, the effective tax rate is higher. If personal income taxes are included, the effective tax rate is between 70% and 80%; the exact figure varies with the tax position of the equityholders and with the form of the shareholder distribution by the insurance company.

Subsections B and C, which show the IRR on the equity flows and the economic value added, are used for performance measurement. For prospective policy pricing, the IRR is constrained to be 12% after-tax and the EVA is zero. Retrospective analysis based on actual results may show a higher or lower IRR and a positive or negative EVA.[7]

MARGINS

The accompanying pie chart shows the relative magnitudes of losses, expenses, taxes, and net profit margin in the policyholder premium.

- The provision for losses and expenses forms the bulk of the premium (91.6%); the gross profit provision is much smaller (8.3%). The insurance industry is about average among firms in the U.S.: supermarkets and department stores have profit margins of about 2%, whereas luxury goods have profit margins of 20% or higher.
- Taxes form the bulk of the gross profit margin; they are 5.1%/(5.1% + 3.2%) = 61.45% of the total. The IRS takes an even larger percentage if reserves are not held at full value.

[7] See Schirmacher and Feldblum [2003], "Retrospective Analysis."

The discretionary assumptions are selected by company management. They are based on financial and actuarial principles, they are not fixed attributes of the block of business. In the companion papers, we present the considerations in selecting each assumption.[8] To properly manage insurance operations and product pricing, one must understand the sensitivity of the target loss ratios to each discretionary assumption.

Illustration: The insurer uses a 12% after-tax return on capital, giving a target combined ratio of 109.2% for first-dollar workers' compensation business. A soft market currently prevails for workers' compensation, and the insurer's management believes that a combined ratio below 112% is not feasible. The company has several options:

A. The company may use a target combined ratio of 109.2% to measure underwriting performance, on the assumption that aggressive targets inspire better performance. This strategy is risky, since unrealistic targets may demoralize employees.
B. The company may reduce the size of its workers' compensation book of business, retaining better quality risks and shunning mediocre risks. In practice, all companies seek to retain better quality risks and shun mediocre risks. Stringent reunderwriting may improve the current year's combined ratio, but it is difficult to win back market share that has been lost during periods of stringent underwriting.[9]
C. The company may decide to accept a lower return on capital for its workers' compensation book of business. Companies rarely achieve all their targets. Astute management foregoes aggressive targets when they collide with business exigencies, as long as the results are still acceptable to the company's owners.

SENSITIVITY ANALYSES

We examine the sensitivity of the target loss ratio and target combined ratio to three of the discretionary pricing assumptions: (i) the benchmark investment yield, (ii) the target return on capital, and (iii) the surplus assumptions.

Target Return on Capital and Benchmark Investment Yield

Exhibit 2 shows the sensitivity of the target combined ratio to changes in (a) the target return on capital (along the vertical axis) and (b) the benchmark investment yield (along the horizontal axis) on both a nominal and discounted basis.

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[8] See particularly the papers on "Benchmark Investment Yield," "Target Return on Capital," "Surplus Requirements," and "Reserve Valuation Rates."

[9] See Feldblum [2002: UCBS]. Stringent underwriting works well if it is based on the long-term expected profitability of the risk. It is of less value if it seeks to weed out average risks during soft markets.

- The nominal basis uses undiscounted premiums, losses, and expenses. This is the combined ratio shown on the company's books.
- The discounted basis uses the ratio of discounted losses and expenses to discounted premiums, using the benchmark investment yield as the discount rate.

The sensitivity to the benchmark investment yield depends on the loss payment pattern for the line of business. The slower the loss payment pattern, the more sensitive is the target loss ratio to the benchmark investment yield.[10]

As the benchmark investment yield increases, the target combined ratio increases. The boxed number in the center of the exhibit, 109.2%, is the target combined ratio at an 8% benchmark investment yield and a 12% target return on capital. As one moves to the right along the row, the benchmark investment yield increases by 50 basis points per column. For a 9% benchmark investment yield (+100 basis points, or two columns to the right), the target combined ratio is 111.8%, or a 250 basis point increase. The increase in the target combined ratio is two and a half times the increase in the benchmark investment yield because the assets supporting the reserves are held for several years.

A higher target combined ratio means a lower indicated premium, since the premium is inversely proportional to the combined ratio. A higher benchmark investment yield means the company is earning more investment income on the insurance transactions, and a smaller underwriting profit margin is needed.

A common – but sometimes misleading – rule of thumb is that the investment yield times the lag between premium collection and loss payment offsets the underwriting income on a one to one basis, after suitable adjustment for expenses and non-investable assets. To avoid potential errors, any pricing rule must consider federal income taxes and changes in the implied equity flows; see below.

Changes in the target return on capital are reflected by movements up and down a column. Each step along a column is a 50 basis point change in the target return on capital. If the benchmark investment yield is 8% per annum, a 100 basis point increase in the target return on capital changes the target combined ratio from 109.2% to 107.8%. More profit is needed in the policyholder premium if equityholders demand a greater return on their invested capital.

For the illustration here, a 100 basis point change in the target return on capital necessitates a 140 basis point change in the combined ratio. This relationship depends on the time that the capital is held; if capital is held for a longer time period, a larger change in the combined ratio is needed. The federal income tax rate affects the relationship, since the combined ratio is on a pre-tax basis and the return on capital is on an after-tax basis.

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[10] The exhibits show the sensitivity for the workers' compensation illustration in Appendix B of Feldblum and Thandi, [2002], "Modeling the Equity Flows."

Exhibit 2

SENSITIVITY ANALYSIS

LINE OF BUSINESS: **Workers' Compensation Fully Insured**

TARGET NOMINAL COMBINED RATIO

Post-Tax ROC = 12.0% +	Investment Rate of Return = 8.0% +										
	-250 bp	-200 bp	-150 bp	-100 bp	-50 bp	0 bp	+ 50 bp	+ 100 bp	+ 150 bp	+ 200 bp	+250 bp
-250 bp	106.2%	107.5%	108.9%	110.2%	111.6%	113.0%	114.5%	116.0%	117.5%	119.1%	120.7%
-200 bp	105.6%	106.9%	108.2%	109.5%	110.8%	112.2%	113.6%	115.1%	116.6%	118.1%	119.7%
-150 bp	105.0%	106.2%	107.5%	108.8%	110.1%	111.4%	112.8%	114.2%	115.7%	117.2%	118.7%
-100 bp	104.4%	105.6%	106.8%	108.1%	109.4%	110.7%	112.0%	113.4%	114.8%	116.3%	117.7%
-50 bp	103.8%	105.0%	106.2%	107.4%	108.7%	109.9%	111.2%	112.6%	114.0%	115.4%	116.8%
0 bp	103.2%	104.4%	105.6%	106.7%	108.0%	109.2%	110.5%	111.8%	113.1%	114.5%	115.9%
50 bp	102.7%	103.8%	104.9%	106.1%	107.3%	108.5%	109.8%	111.0%	112.4%	113.7%	115.1%
100 bp	102.1%	103.2%	104.3%	105.5%	106.6%	107.8%	109.1%	110.3%	111.6%	112.9%	114.2%
150 bp	101.6%	102.6%	103.7%	104.9%	106.0%	107.2%	108.4%	109.6%	110.8%	112.1%	113.4%
200 bp	101.0%	102.1%	103.2%	104.2%	105.4%	106.5%	107.7%	108.9%	110.1%	111.3%	112.6%
250 bp	100.5%	101.5%	102.6%	103.7%	104.7%	105.9%	107.0%	108.2%	109.4%	110.6%	111.8%

SPREAD PRICING

Life actuaries often conceive of the profit margin in terms of a spread between the earned interest rate (adjusted for expenses and investment risks) and the credited interest rate. The pricing of annuity products is primarily the selection of the appropriate spread.

Illustration: The pricing actuary may target a 200 basis point spread for a variable annuity product. During the accumulation phase, the insurer credits the account balance with the earned interest rate minus 200 basis points. At the commencement of the payout phase, the expected periodic benefits are determined from the assumed interest rate, which is the current earned interest rate minus 200 basis points. During each subsequent year, the annuity benefits are adjusted by the ratio of that year's earned interest rate minus 200 basis points to the assumed interest rate. The actual achieved spread may vary with market demand for the annuity product and with competitive pressures for similar investment vehicles.

An analogous procedure suggested for property-casualty products would be to set a target spread between the return on capital and the benchmark investment yield. The target combined ratio would depend on the size of this spread.

This procedure presumes that if a 109% target combined ratio is appropriate for an 8% benchmark investment yield and a 12% target return on capital, it is also appropriate for a 10% benchmark investment yield and a 14% target return on capital and for a 6% benchmark investment yield and a 10% target return on capital. In other words, the target combined ratio depends on the spread between the benchmark investment yield and the target return on capital, not on the absolutes values of either figure. Since the benchmark investment yield and the target return on capital both vary with the risk-free interest rate, this simplifies the pricing.

Although a spread perspective is reasonable for universal life policies and for certain annuity products, it is misleading for property-casualty insurance products. The general rule is that

> *Spread pricing is appropriate for tax exempt products and for tax deferred products with long durations; common examples are life insurance policies, variable annuities, and pension products. It is also appropriate for pass-through financial intermediaries, such as mutual funds, investment houses, and certain depository institutions. It is incorrect for fully taxable products, such as property-casualty policies, and it may lead to severe under-pricing as interest rates increase.*

Spread pricing is most appropriate when customer funds are treated (for tax purposes) as deposits, not as revenue, and when the investment income earned by the financial intermediary is either tax deferred (or tax exempt) or passed through to the customer. These conditions are true for most financial institutions, such as life insurance companies, annuity writers, depository institutions, mutual funds, and investment houses. For property-casualty products, the policyholder premium is treated as revenue, not as a deposit, and all investment

income is taxed at the corporate level before being passed to policyholders or equityholders.[11]

We examine the relationship between a constant spread and the target combined ratio, using both full value and discounted figures. We then explain the observed results, with emphasis on the federal income tax effects for property-casualty products.

Constant Spread and Full Value Targets

A constant spread is represented by a diagonal line running from the upper left to the lower right in Exhibit 2. The following pair of entries both represent a spread of 400 basis points.

- For a benchmark investment yield of 8% per annum and a target return on capital of 12% per annum, the target combined ratio is 109.2%.
- For a benchmark investment yield of 9% per annum and a target return on capital of 13% per annum, the target combined ratio is 110.3%.

With a constant spread of 400 basis points between the target return on capital and the benchmark investment yield, the target combined ratio increases by 100 basis points for a 100 basis point increase in the target assumptions.

Constant Spread and Discounted Targets

In Exhibit 2, the target combined ratio is expressed in nominal dollars. When interest rates increase, an insurer can afford to write business at a higher combined ratio. This does *not* mean that the insurer can afford to write the business at a lower premium rate, since the higher combined ratio is discounted at a higher rate.

Exhibit 3 shows the sensitivity of the discounted target combined ratio to the benchmark investment yield and the target return on capital.[12] For a constant spread of 400 basis points, a change in the pricing assumptions (return on capital and benchmark investment yield) is represented by a diagonal line through the center square.

- For a benchmark investment yield of 8% per annum and a target return on capital of 12% per annum, the target discounted combined ratio is 91.6%.
- For a benchmark investment yield of 9% per annum and a target return on capital of 13% per annum, the target discounted combined ratio is 91.2%.

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[11] SFAS 60, applicable to traditional life insurance products and to property-casualty products, treats premium as revenue. SFAS 97, applicable to universal life-type products and investment contracts, treats premium as a deposit.

[12] The discounted combined ratio uses discounted losses and expenses divided by discounted premiums.

Exhibit 3

SENSITIVITY ANALYSIS

LINE OF BUSINESS: **Workers' Compensation Fully Insured**

TARGET DISCOUNTED COMBINED RATIO

Post-Tax ROC = 12.0% +	Investment Rate of Return = 8.0% +										
	-250 bp	-200 bp	-150 bp	-100 bp	-50 bp	0 bp	+ 50 bp	+ 100 bp	+ 150 bp	+ 200 bp	+250 bp
-250 bp	93.0%	93.2%	93.5%	93.8%	94.2%	94.6%	95.0%	95.4%	95.9%	96.4%	97.0%
-200 bp	92.5%	92.7%	93.0%	93.3%	93.6%	93.9%	94.3%	94.8%	95.2%	95.7%	96.2%
-150 bp	92.0%	92.2%	92.4%	92.7%	93.0%	93.3%	93.7%	94.1%	94.6%	95.0%	95.5%
-100 bp	91.5%	91.7%	91.9%	92.2%	92.4%	92.8%	93.1%	93.5%	93.9%	94.4%	94.8%
-50 bp	91.0%	91.2%	91.4%	91.6%	91.9%	92.2%	92.5%	92.9%	93.3%	93.7%	94.2%
0 bp	90.5%	90.7%	90.9%	91.1%	91.4%	91.6%	92.0%	92.3%	92.7%	93.1%	93.5%
50 bp	90.1%	90.2%	90.4%	90.6%	90.8%	91.1%	91.4%	91.7%	92.1%	92.5%	92.9%
100 bp	89.6%	89.7%	89.9%	90.1%	90.3%	90.6%	90.9%	91.2%	91.5%	91.9%	92.3%
150 bp	89.2%	89.3%	89.4%	89.6%	89.8%	90.1%	90.3%	90.6%	90.9%	91.3%	91.7%
200 bp	88.7%	88.8%	89.0%	89.1%	89.3%	89.6%	89.8%	90.1%	90.4%	90.7%	91.1%
250 bp	88.3%	88.4%	88.5%	88.7%	88.9%	89.1%	89.3%	89.6%	89.9%	90.2%	90.5%

Even though the spread between the return on capital and the investment yield has not changed, the target discounted combined ratio declines by 40 basis points for a 100 basis point increase in the pricing assumptions. As the nominal investment yield increases, the insurance policy becomes less profitable. The decrease in profitability depends on the loss payment pattern of the line of business.

This effect stems from the federal income tax on investment income, and its magnitude varies directly with the taxability of the product. The policy reserves for life insurance and annuity products enjoy a tax deferred inside build-up, so this relationship is relatively weak. Similarly, mutual funds are not taxed at the corporate level; the investment income is passed through to investors. In contrast, the investment income of property-casualty insurers is fully taxed.

Spread Pricing and Federal Income Taxes

We explain the intuition by a pair of illustrations. For the illustrations, we assume a 200 basis point differential between the inflation rate and the risk-free interest rate and a constant spread of 400 basis points between the target return on capital and the risk-free interest rate.

Illustration A: An insurer writes commercial liability lines of business and invests in Treasury securities. The premium to surplus ratio is 1.5 to 1, and the expected loss ratio is 66.7%. We assume first that the inflation rate is 0% per annum, the investment yield (the risk-free interest rate) is 2% per annum, and the target return on capital is 6% per annum.

- The nominal pre-tax investment yield is 2% per annum.
- The nominal after-tax investment yield is $2\% \times (1 - 35\%) = 1.30\%$ per annum.
- The real after-tax investment yield is $\{[1 + 2\% \times (1 - 35\%)] / 1.000\} - 1 = 1.30\%$ per annum. Since inflation is 0% per annum, the real yield equals the nominal yield.
- The cost of holding capital is the target return on capital minus the after-tax investment yield, or $6.00\% - 1.30\% = 4.70\%$. This is the extra return demanded by equityholders.
- The premium to surplus ratio for the policy is 1.5 to 1. The policy must provide a $4.70\% / 1.5 = 3.13\%$ after-tax return on premium or a $3.13\% / (1 - 35\%) = 4.82\%$ pre-tax return on premium. This is the profit loading on a discounted basis.
- The premium is collected at policy inception. The profit loading valued at the inception of the year is $4.82\%/1.02 = 4.73\%$.

Illustration B: The scenario remains the same, but the inflation rate is 10% per annum, the investment yield is 12% per annum, and the target return on capital is 16% per annum.

- The nominal pre-tax investment yield is 12% per annum.
- The nominal after-tax investment yield is $12\% \times (1 - 35\%) = 7.80\%$ per annum.
- The real after-tax investment yield is $\{[1 + 12\% \times (1 - 35\%)] / 1.100\} = -2.00\%$ per annum.

- The cost of holding capital is 16.00% – 7.80% = 8.80%.
- With a 1.5 to 1 premium to surplus ratio, the insurance policy must provide an 8.80% / 1.5 = 5.87% after-tax return or a 5.87% / (1 – 35%) = 9.03% pre-tax return.
- The profit loading valued at the inception of the year is 9.03%/1.12 = 8.06%

In both scenarios, the profit loading is the percentage of the premium that funds the cost of holding capital. The remainder of the premium funds the discounted losses and expenses. This profit margin is on a discounted basis, not a nominal basis. The difference in the profit loading is 8.06% – 4.73% = 3.33%.

If the spread between the target return on capital and the benchmark investment yield is 400 basis points, the profit margin in the premium must be 333 basis points higher when the investment yield is 12% than when the investment yield is 2%. This difference stems from the effects of corporate income taxes on nominal returns.

SENSITIVITY: SURPLUS ASSUMPTIONS

The target combined ratio is sensitive to the surplus assumptions. The surplus assumptions for casualty pricing models are generally implemented as leverage ratios: a certain percentage of premium and a certain percentage of losses.

The surplus assumptions affect the indicated premium through the cost of holding capital. If the company requires more capital from its equityholders, the dollar cost of holding capital increases. The multiple layers of taxation – on underwriting income and on investment income – provide a multiplier effect. For each additional dollar paid to equityholders, the IRS takes about $1.50, and the policyholder must pay about $2.50.

Exhibit **4** shows the sensitivity of the target combined ratio to the premium leverage ratio for the workers' compensation book of business in Appendix B of Feldblum and Thandi, [2002], "Modeling the Equity Flows." The boxed target combined ratio in the middle of the exhibit corresponds to a premium leverage ratio of 43.7% and a benchmark investment yield of 8% per annum. Moving up or down a column changes the premium leverage ratio by increments of 500 basis points.

- Adding 500 basis points to the premium leverage ratio reduces the target combined ratio by 60 basis points, from 109.2% to 108.6%.
- Subtracting 500 basis points to the premium leverage ratio increases the target combined ratio by 60 basis points, from 109.2% to 109.8%.

Two factors mitigate this sensitivity:

Exhibit 4

SENSITIVITY ANALYSIS

LINE OF BUSINESS: **Workers' Compensation Fully Insured**

Post-Tax Return on Equity	12.0%

TARGET NOMINAL COMBINED RATIO

Premium Leverage Ratio = 43.7% +	Investment Rate of Return = 8.0% +										
	-250 bp	-200 bp	-150 bp	-100 bp	-50 bp	0 bp	+ 50 bp	+ 100 bp	+ 150 bp	+ 200 bp	+250 bp
-1500 bp	105.4%	106.4%	107.6%	108.7%	109.9%	111.0%	112.3%	113.5%	114.8%	116.1%	117.4%
-1000 bp	104.7%	105.8%	106.9%	108.0%	109.2%	110.4%	111.7%	112.9%	114.2%	115.6%	116.9%
-500 bp	103.9%	105.1%	106.2%	107.4%	108.6%	109.8%	111.1%	112.4%	113.7%	115.0%	116.4%
0 bp	103.2%	104.4%	105.6%	106.7%	108.0%	[illegible]	110.5%	111.8%	113.1%	114.5%	115.9%
+500 bp	102.5%	103.7%	104.9%	106.1%	107.3%	108.6%	109.9%	111.2%	112.6%	114.0%	115.4%
+1000 bp	101.8%	103.0%	104.2%	105.5%	106.7%	108.0%	109.3%	110.7%	112.1%	113.5%	114.9%
+1500 bp	101.1%	102.3%	103.6%	104.8%	106.1%	107.4%	108.7%	110.1%	111.5%	113.0%	114.4%

- For the long-tailed lines of business, only part of the equityholder provided capital is contained in surplus. Additional capital is embedded in the statutory loss reserves and unearned premium reserves. If loss reserves are held on a full value basis, the capital embedded in workers' compensation loss reserves significantly exceeds the capital in the workers' compensation risk-based capital requirements.
- To facilitate performance measurement and incentive compensation systems, the exhibits in Appendix B of Feldblum and Thandi, [2002], "Modeling the Equity Flows," allocate capital based on written premium, not based on held reserves; Feldblum and Thandi [2002] "Surplus allocation." The capital in surplus is held for a single year, whereas the capital embedded in full value loss reserves is held as long as the claim remains unpaid.

The other three discretionary assumptions in the pricing model – the target return on capital, the benchmark investment yield, and the loss reserve valuation rate – affect the policy throughout its life. The surplus assumption has only a partial effect for one year.

The effects of the loss reserve valuation rate on the target loss and combined ratios is more intricate, partly because of the tax effects caused by implicit discounting of reserves. See Feldblum and Thandi [2002] "Federal Income Taxes and the Cost of Holding Capital," for a complete discussion of this topic.