INVESTMENT INCOME IN RATEMAKING IN MASSACHUSETTS (SEMINAR ON PROFITABILITY, 4/91)

Howard Mahler

The issue of profitability of the major lines of Automobile and Workers' Compensation insurance in Massachusetts has been handled on an ex-ante formula basis since 1975. Beginning with Commissioner James M. Stone's Automobile Bodily Injury/Liability Decision for 1976 state set rates, explicit account has been taken of investment income. Although the computational techniques have changed over the years, the common thread has been to attempt to allow insurers a fair return on their equity.

The Myers-Cohn Model

The Myers-Cohn net present value model was developed for the Massachusetts Rating Bureaus by Stewart Myers and Richard Cohn.[1] It was intended as an improvement of the Fairley model which was used previously.[2] The basic concepts underlying the Fairley model, the model shown in my Proceedings paper "An Introduction to Underwriting Profit Models"[3] and the Myers-Cohn model are all similar. Given similar inputs all three models give similar (but not identical) results. The Myers-Cohn model was first presented in the Fall of 1981 at the 1982 automobile rate hearings. Then Commissioner Sabbagh used a modified version

---

[1]The model was implemented for use in Massachusetts by Richard Derrig of the Rating Bureaus.

[2]The original Fairley Model, an improvement by Hill and Modigliani, and the Myers-Cohn Model, are all presented in Fair Rate of Return in Property-Liability Insurance, Kluwer-Nijhoff, 1986.

[3]PCAS LXXII, 1985. The model presented in the spring of 1981. It is described as "Model A" in Part III of the 1984 NAIC Study of Investment Income.

of this model to fix and establish the 1982 automobile rates. The Massachusetts Rating Bureaus used the Myers-Cohn model to derive its proposed Workers' Compensation underwriting profit provision as well. It is currently used, with some technical refinements, to set profit provision for both Automobile and Workers' Compensation insurance in Massachusetts.

The basic premise underlying the Myers-Cohn model can be stated this way: a fair premium must be equal to the expected losses and expenses, discounted to present value at a risk-adjusted rate, plus the present value of the Federal income taxes on underwriting and investment income, discounted at a risk-free rate. Premiums calculated this way should preserve the equity invested in the company and give the investor a fair return for the risk of underwriting by the company.

Simple Example, Profit Provision

In order to illustrate the use of the Myers-Cohn model, I will first present a simplified example. After that I will show what was done in the most recent Massachusetts Workers' Compensation rate filing.

It is neither the purpose nor intention of this talk to defend or justify what was done. For purposes of this talk you should view all inputs chosen and calculated profit provisions as solely for illustrative purposes. As with all profit models, the profit provision calculated using the Myers-Cohn model is very sensitive to the inputs chosen and assumptions made. Later in the talk, I will illustrate this sensitivity.

For this simplified example, I will make the following assumptions: All premiums are collected in quarter 1. All losses are paid in quarter 5. Variable expenses are 20% of premiums, and are paid in quarter 2. The ratio of fixed expenses to losses is 5%. Fixed expenses are paid in quarter 2. Loss adjustment expenses are 10% of losses, and are paid when losses are in quarter 5. There is no discounting of reserves (for tax purposes) and no taxing of the unearned premium reserve. There are no dividend payments.

The risk free rate is assumed to be 9%. (Presumably this was determined from rates of return available on duration matched Treasury Securities.) This is combined with an assumed Beta of Underwriting of -.2 and a Market Risk Premium of 10%, to get a risk adjusted rate of 7%. 7% = 9% - .2 x 10%. While this is based on the Capital Asset Pricing Model, some other means could be used to get the risk adjusted rate. The important concept is that discounting "risky" loss and expense flows at the smaller risk adjusted rate is intended to compensate insurers for the risk of underwriting insurance.

A 2 to 1 initial premium to surplus ratio is chosen. The surplus allocated to this policy is assumed to decline in proportion to the losses and expenses paid.

Using the Myers-Cohn profit model the calculated underwriting profit provision is -4.7% as shown in Exhibit 1. However, the purpose of this example is to illustrate and help to understand the method of calculation, rather than concentrate on the answer itself. Exhibits 2, 3 and 4 show in detail how the cashflows are constructed and how the Kappa values are determined. The Kappa values are "timing parameters." They are calculated by discounting the various cashflows at either the risk free or risk adjusted rate. Exhibit 2 shows the cashflows for the initial set of weights.[4] However, as the profit provision varies so does the relative weight given to variable expenses, so that the profit model is solved via iteration. Exhibit 4 shows the cashflows for the final weights.

Let's go through these exhibits in some detail. The top portion of Exhibit 1 shows the inputs and assumptions I have chosen for this example. Next are shown the various kappa values, which are defined in Exhibit 5.[5]

The calculation of the kappa values is shown in Exhibit 3, for the initial weights. κ_1 is the risk adjusted discounted loss and expense factor. We take the loss and expense flows from Exhibit 2 and discount them at the risk adjusted rate of 7%. (We divide the result by the sum of losses and expenses, which has been selected as 1000.)

---

[4]The cashflows are constructed for a single policy (or set of policies with the same effective date), with a policy effective period of Quarters 1, 2, 3, and 4. Thus the policy effective date (time = 0) is at the end of Quarter 0, and the beginning of Quarter 1.

[5]The Myers-Cohn paper had only four kappas. One additional kappa was introduced in implementation to allow for the difference in timing between the payment of losses and expenses, and the timing of the tax consequences of incurring losses and expenses. $\kappa_1 \neq \kappa_5$. κ_6 was introduced in order to take into account the "revenue offset" feature of the Tax Reform Act of 1986.

κ_2 is the result of discounting the premium flow at the 9% risk free rate.

κ_3 is the result of discounting the investment balance for taxes at the risk free rate. The investment balance for taxes shown on Exhibit 2 is the sum of the surplus plus the premium dollars collected that have yet to be paid out as losses plus expenses.

κ_4 is the discounted contribution of premiums to the underwriting profit tax. κ_5 is similar but for losses and expenses, and thus discounted at a risk adjusted rate. Here it's assumed these take place evenly in the four policy quarters.

κ_6 is the discount factor for the taxing of the change in unearned premium reserve.

On the bottom portion of Exhibit 1 is shown how the different factors are put together into a formula to calculate the ratio of premiums to losses and expenses and in turn the underwriting profit provision. Those terms involving losses and expenses are in numerator. The terms involving taxes of course include the tax rates τ_1 = underwriting tax rates or τ_2 = investment income tax rate.

The term $\tau_2 r\kappa_3$ is the tax rate τ_2 times the investment income of $r\kappa_3$, which is the quarterly rate of return times the (discounted) investment balance.

Once the ratio of P/(L+E) is calculated as .95541 the profit provision is 1-(1/.95541) = -4.7%. This can be thought of as a target combined ratio of 104.7% for this fictional example.

Filing for 1/1/91 Rates

Exhibits 5 through 8 are extracts from the filing for 1/1/91 Massachusetts Workers' Compensation rates. It should be noted that these are only the four summary pages out of a total of 168 pages in the profit section of that filing.

Exhibit 5 shows the definition of the variables and the equations for the Myers-Cohn model.

Exhibit 6 summarizes the inputs and the result. Unfortunately, the various cashflows which are shown in the rate filing, are too lengthy to be shown here. The Myers-Cohn model with the selected inputs produces a profit provision of -6.5%. To this was added an adjustment of 1.2% in order to cover investment expenses. (These expenses could be considered either in the setting of the profit provision or elsewhere in the rate filing.)

The footnotes on Exhibit 6 also mention two technical refinements introduced into the model. The risk adjustment decreases linearly to zero after quarter 5, as does the surplus/premium ratio. The model itself is flexible enough to accept any vector of risk adjusted rates by quarter as well as any form of surplus flow.

Exhibit 7 shows the kappa values and the computation of the -6.5% model profit provision. Again, let me state that for purposes of this talk, this -6.5% is just an illustrative number which may or may not be appropriate for any real world application.

Exhibit 8 calculates that the proposed -5.3% profit provision (including the adjustment for investment expenses) is expected to produce a post-dividend combined ratio to premiums (net of premium discount) of 110%.

Sensitivity Analysis

Exhibit 9 shows the sensitivity of the Myers-Cohn model to the choice of different inputs.

The risk free rate of return can vary by several percent from one year to the next. Generally, we have used an average of the last year's worth of rates available on a duration matched portfolio of treasury securities to estimate the risk free rate. For long-tailed lines like Workers Comp., a 1% change in interest rate produces more than a 1% change in profit provision.

If one assumed that underwriting was risk free (beta of underwriting equal to zero), there would be a more negative profit provision. The difference between this profit provision and the calculated profit provision represents the reward for taking the risk of writing insurance.

The investment income tax rate and premium to surplus ratio are other important and sometimes controversial inputs.

The tax reform act of 1986 introduced the discounting of loss reserves for tax purposes and the taxing of the unearned premium reserve. As expected, since each of these changes was intended to produce more taxes for the federal government, they each lead to a less negative underwriting profit provision. Insurers need more money to pay these taxes, all other things being equal.

Finally, the timing of the loss payments is an extremely important input. Changing this timing by one quarter of a year changes the profit provision by almost 1%. By the way, for Workers' Compensation we estimate that the average loss payment occurs approximately four years from policy inception.

Future Work

The Myers-Cohn model has been used in Massachusetts for approximately the last decade. During that time a number of refinements have been made for the purposes of various applications of the model. I've mentioned a few today.

Among the things the Workers' Compensation Rating Bureau has been investigating is what expected rate of return on equity is implied by the use of a profit provision calculated via the Myers-Cohn model. We have concluded that there is no unique rate of return on equity associated with any particular Myers-Cohn calculation. However, we are working through the additional assumptions that have to be made in order to assign a range of rates of return.

Conclusion

In Massachusetts the Myers-Cohn model has been used to set many profit provisions over the last decade. As with any profit model, in any real world application, one must carefully examine the underlying assumptions and inputs to make sure that everything is consistent. It has proven very easy for two people to get extremely different profit provisions using the same model.[6] The last decade has demonstrated the impossibility of coming up with either a universally accepted profit model or profit provision. However, the possibility of differing answers no more makes profit models useless, than would the inability to agree on exactly how to predict future loss levels make trending and loss development techniques useless. Profit models provide a framework for a rational discussion and allow the testing of the affect of changes to the tax law, investment policy, claims payment patterns, economic conditions, etc.

---

[6]Even when using the same profit model for Workers' Compensation Insurance, disagreements of 10% or more in proposed profit provisions are not unheard of.

 Exhibit 1

Myers-Cohn Profit Model

Example of Calculation of Underwriting Profit Provision

Inputs

Risk Free Rate = 9%
Beta of Underwriting = -.20
Market Risk Premium = 10%
Risk Adjusted Rate = 9% - .20 x 10% = 7%
Premium to Surplus ratio = 2
Federal Income Tax Rate on Underwriting = 34%.
Federal Income Tax Rate on Investment = 25%.
Expenses (other than loss adjustment expense) are all paid in quarter 2.
Variable Expenses are 20% of Premium.
Fixed Expenses are 5% of Losses.
Loss Adjustment Expense is 10% of Losses.
Premiums are all collected in quarter 1.
Losses and loss adjustment expense are all paid in quarter 5.
There are no Dividends paid.
There is no discounting of reserves (for tax purposes).
There is no taxing of the unearned premium reserve; alpha = 0.

Kappas	Initial Weights	Final Weights
κ_1 =	.938033	.937621
κ_2 =	.989286	.989286
κ_3 =	4.893530	4.929088
κ_4 =	.947839	.947839
κ_5 =	.958762	.958765
κ_6 =	.978686	.978686

Profit Provision

$$\frac{P}{L+E} = \frac{\kappa_1 - \tau_1\kappa_5}{\kappa_2 - \tau_2 r\kappa_3 - \tau_1 \kappa_4 - \tau_1 \alpha \kappa_6}$$

$$= \frac{.937621 - .34(.958765)}{.989286-(.25 \times .021778 \times 4.929088)-(.34 \times .947839)-(.34 \times 0 \times .978686)}$$

$$= .95541$$

$$\mu = 1 - (P/(L+E))^{-1} = -4.7\%$$

Example Cashflows
(Initial Weights)

Quarter	Premiums	Losses	Expenses*	Cumulative Difference	Surplus	Investment Balance**
0	0	0	0	0	250.00	250.00
1	1000.00	0	0	1000.00	500.00	1500.00
2	0	0	234.78	765.22	382.61	1147.83
3	0	0	0	765.22	382.61	1147.83
4	0	0	0	765.22	382.61	1147.83
5	0	695.65	69.57	0	0	0
	1000.00	695.65	304.35			

The policy inception date is at the end of quarter zero and the beginning of quarter one.

*Expenses are the sum of 200 (20% of premium) representing variable expense in quarter 2, 34.78 (5% of losses) representing fixed expense in quarter 2, and 69.57 (10% of losses) representing l.a.e. in quarter 5. Note that for the initial weights, losses plus expenses = 1000 = premiums.

** Investment Balance is the sum of the surplus and the cumulative difference of premiums and losses.

Example Calculation of Kappas (Initial Weights)

κ_1 = risk adjusted discounted losses and expenses factor

$.76522 \times (1.07)^{4.5+4}$

$+ .23478 \times (1.07)^{-1.5+4}$

= .9380

Note: Losses and loss adjustment expenses discounted to the middle of the fifth quarter. Expenses discounted to the middle of the second quarter.

κ_2 = risk free discounted premiums factor

= Discounted Value of Premium Flow

= .9893

Note: Discounting to the middle of the first quarter

$.9893 = (1.09)^{-.5+4}$

κ_3 = risk free discounted investment balance tax factor

= Discounted Investment Balance for Taxes

= (250x.9893)+(1500x.9682)+(1147.83x.9476)+(1147.83x.9274)+(1147.83x.9076)

= 4.8935

κ_4 = risk free underwriting profit tax factor (contribution of premiums)

= (.25x.9787)+(.25x.9578)+(.25x.9374)+(.25x.9174)

= .9478

Note: Discounting to the end of the first, second, third, and fourth quarters.

κ_5 = risk adjusted discounted underwriting profit tax factor (contribution of losses and expenses)

= (.25x.9832)+(.25x.9667)+(.25x.9505)+(.25x.9346)

= .9588

Note: Discounting to the end of the first, second, third, and fourth quarters.

κ_6 = risk free discounted unearned premium tax factor

= .9787

Note: Discounting to the end of the first quarter

Example Cashflows
(Final Weights)

Quarter	Premiums*	Losses	Expenses**	Cumulative Difference	Surplus	Investment Balance***
0	0	0	0	0	250.00	250.00
1	1000.00	0	0	1000.00	500.00	1500.00
2	0	0	226.25	773.75	386.87	1160.62
3	0	0	0	773.75	386.87	1160.62
4	0	0	0	773.75	386.87	1160.62
5	0	703.41	70.34	0	0	0
	1000.00	703.41	296.59			

The policy inception date is at the end of quarter zero and the beginning of quarter one.

* Premiums shown are prior to the profit loading. The premium loaded for profit is 955.41.

** Expenses are the sum of 191.08 (20% of premiums loaded for profit of 955.41) representing variable expense in quarter 2, 35.17 (5% of losses) representing fixed expense in quarter 2, and 70.34 (10% of losses) representing l.a.e. in quarter 5. Note that losses plus expenses = 1000.

*** Investment Balance is the sum of the surplus and the cumulative difference of premiums and losses.

Massachusetts Workers' Compensation

WCRB Formulation of the Myers-Cohn: 1987 Tax Law
<u>Cost of Capital Underwriting Profit Provision Model</u>[1]

Let <u>Flows</u>

P = Premium
L = Losses
E = Expenses
IVB = Investment Balance
IVBT = Investment Balance for Tax
UWP = Underwriting Profit

<u>Capital Market Rates</u>

r = Risk Free Rate
r_L = Risk-Adjusted Rate (Adjusted for Risk of Underwriting by Line)
τ_1 = Federal Underwriting Income Tax Rate
τ_2 = Federal Investment Income Tax Rate
μ = Underwriting Profit Margin
α = Unearned Premium Reserve Factor for Taxes

Then, given the basic valuation equations of The Myers-Cohn model,

(1) Present Value of Premium = Present Value of Losses and Expenses plus Present Value of Federal Tax Liabilities on Underwriting Profits and Investment Income on the Investment Balance.

or

(1)' $PV(P) = PV(L + E) + PV\,(UWP\ \tau_1) + PV\,(IVBT\ r\tau_2)$

Where,

the investment balance flow, IVB, is defined as the funds available for investment from the policy cash flow, cumulative premium minus cumulative losses, plus those funds available from other supporting assets. IVBT is IVB advanced one quarter to the time period when the income is earned and the tax liability is incurred.

Then, if premiums and investment income are valued at the risk free rate r, losses and expenses valued at a risk adjusted rate; underwriting and investment income taxed at rates τ_1 and τ_2 ; and underwriting profits taxed using after-dividend premiums and discounted loss reserves:

(2) $$PV_r\,(P) = PV_{r_L}\,(L+E) + PV_r(P\ \tau_1\ UWP/(P-(L+E))) - PV_{r_L}\,((L+E)\tau_1\ UWP/(P-(L+E))) + PV_r\ \ (r\tau_2\ (IVBT))$$

or

(2)' $$\frac{P}{L+E} = \frac{\kappa_1 - \tau_1\kappa_5}{\kappa_2 - \tau_2\, r\kappa_3 - \tau_1\,\kappa_4 - \alpha\,\tau_1\,\kappa_6}$$

and $\mu = 1-(P/(L + E))^{-1}$

Where κ_1 = risk adjusted discounted losses and expenses factor
κ_2 = risk free discounted premiums factor excluding policyholder dividends
κ_3 = risk free discounted investment balance tax factor
κ_4 = risk free discounted underwriting profit tax factor
κ_5 = risk adjusted discounted underwriting profit tax factor
κ_6 = risk-free discounted unearned premium tax factor

1 Chapter 3 of J.D. Cummins and S.E. Harrington, eds., <u>Fair Rate of Return on Property-Liability Insurance</u>, Hingham, Mass., Kluwer-Nijhoff, 1986.

Massachusetts Workers' Compensation

Filing for 1/1/91 Rates

Model Profit Allowance	-6.5%
Adjustment for Investment Expenses	1.2%
Underwriting Profit Allowance	-5.3%

Parameters

Capital Market Rates	
Risk-Free Rate	8.39%
Risk-Adjusted Rate (Beta = -.21, Market Risk Premium 9%)	6.50%*
Federal Tax Rates (Post Tax Reform Act of 1986)	
Underwriting	34%
Investment	28.2%
Premium/Surplus Ratio	2 to 1**
Policyholder Dividends (as a percent of Net Premium)	4.19%
Policyholder Dividends (as a percent of Standard Premium)	3.75%

---

* Risk-Adjusted rate for quarters -3 through 5. Risk-adjusted rate increases linearly to the risk free rate from quarter 5 to the end of the loss and expense flow. Equivalently, the absolute value of beta decreases linearly to zero.

** Consistent with the change in the risk-adjusted rate, the surplus/premium ratio decreases linearly to zero from quarter 5 to the end of the loss and expense flow.

Exhibit 7

Massachusetts Workers' Compensation

Filing for 1/1/91 Rates

Calculation of Underwriting Profit Provisions
Using Myers-Cohn Cost of Capital Model

$$\frac{P}{L+E} = \frac{\kappa_1 - \tau_1 \kappa_5}{\kappa_2 - \tau_2 r \kappa_3 - \tau_1 \kappa_4 - \tau_1 \alpha \kappa_6}$$

$$\mu = 1 - (P/(L+E))^{-1}$$

$r = .020346$ $r_L = .015868$ $\tau_1 = .34$ $\tau_2 = .282$ $\beta = -.21$ $\alpha = .010511$

Discounting Factors

$\kappa_1 = .808618$
$\kappa_2 = .919674$
$\kappa_3 = 13.376$
$\kappa_4 = .917902$
$\kappa_5 = .921415$
$\kappa_6 = .943307$

$$\frac{P}{L+E} = \frac{.808618 - .34(.921415)}{.919674 - .282(.020346)(13.376) - .34(.917902) - .34(.010511)(.943307)}$$

$= .939080$

$\mu = 1-(.939080)^{-1} = -.0649$

Model Provision = -6.5%

Massachusetts Workers' Compensation

Filing for 1/1/91 Rates

1.	Expected Manual Underwriting Ratio	105.30%
2.	Expected Premium Discount	10.50%
3.	Expected Discount as Proportion of L+E	9.86%
4.	Expected Net Underwriting Ratio (1) x (1-(3))/(1-(2))	106.05%
5.	Expected Net Dividend Ratio	4.19%
6.	Expected Target Underwriting Ratio (post dividend) (4) + (5)	110.24%

Exhibit 9

Sensitivity Analysis
Myers - Cohn Profit Model

Base Case: Filing for 1/1/91 MA W.C. Rates

Risk Free Rate	Model Profit Provision	Difference
10.39%	-9.5%	-3.0%
8.39%	-6.5%	Base
6.39%	-3.1%	+3.4%
Beta of Underwriting		
-.11	-9.3%	-2.8%
-.21	-6.5%	Base
-.31	-3.7%	+2.8%
Investment Income Tax Rate		
26.2%	-7.6%	-1.1%
28.2%	-6.5%	Base
30.2%	-5.3%	+1.2%
Underwriting Income Tax Rate		
36%	-6.7%	-.2%
34%	-6.5%	Base
32%	-6.3%	+.2%
(Initial) Premium to Surplus Ratio		
3	-8.5%	-2.0%
2	-6.5%	Base
1	-.5%	+6.0%
Policyholder Dividends		
0	-11.0%	-4.5%
3.75%	-6.5%	Base
7.50%	-2.0%	+4.5%
Loss Reserves for Tax Purposes		
No Discounting	-9.7%	-3.2%
Discounting as per TRA '86	-6.5%	Base
Taxing of the Unearned Premium Reserve		
None	-7.2%	-.7%
As per TRA '86	-6.5%	Base
Timing of Loss Payments		
One Quarter Later	-7.4%	-.9%
As per rate filing	-6.5%	Base
One Quarter Earlier	-5.7%	+.8%