# AN ANALYSIS OF RETROSPECTIVE RATING

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In the opening of his paper "An Analysis of Retrospective Rating," Glenn Meyers asks the following question:

> "Should the present retrospective rating formula be modified to account for the claim severity distribution for the risk being insured, and for the loss limit chosen for the plan?"[1]

People experienced in pricing large casualty accounts are aware of these problems with the current rating formula. Reacting to competitive pressures, they are turning to the actuary and are no longer asking *should* the formula be changed, but *how* can it be changed to more equitably price the risk involved. These competitive pressures from within the industry and from outside of the industry in the form of self-insurance make this paper a timely and important contribution to our Society's literature.

Meyers begins by selecting three claim severity distributions reflecting low, medium, and high severity insureds. These hypothetical distributions are combined with a Poisson frequency distribution to demonstrate how our present retrospective rating formula fails to react to the differences in the severity distributions and, how it also can overcharge when loss limitations are included in the plan. Using several sets of retrospective rating plan parameters, he quantifies the retrospective rating premium adequacy for the three underlying severity distributions, with and without loss limitations. The author has found that with the proper excess loss premium factors, the remaining insurance charges are approximately equal regardless of the underlying severity distribution.

In the last part of his paper, the author discusses several possible changes to the retrospective rating formula. The alternative I believe holds the most promise is to generate a number of limited insurance charge tables to be used in conjunction with the full excess loss premium factors. For practical reasons,

[1] Glenn G. Meyers, "An Analysis of Retrospective Rating," *PCAS* LXVII, 1980, p. 110.

he suggests that the industry restrict the number of loss limitations to be offered. It might even be necessary to mandate one loss limitation if adverse selection causes the excess loss premium factors to be significantly inadequate.

Before addressing specific points in the paper, it is necessary to define some terms used throughout this discussion. The term "net insurance charge" refers to the provision built into the basic premium factor to collect the cost of limiting the retrospective premium to the maximum or minimum premium. The net insurance charge is equal to:

(Charge − Savings) × (Permissible Loss Ratio) × (Loss Conversion Factor)

In a retrospective rating plan with a loss limitation, the net insurance charge includes a provision for limiting the losses per occurrence. The term "limited insurance charge" refers to the difference between the net insurance charge and the loss limitation charge [(Excess Loss Premium Factor) × (Loss Conversion Factor)].

Glenn Meyers' conclusion that the limited insurance charges are nearly equal for a given retrospective rating plan regardless of the underlying severity distribution is quite noteworthy. In an attempt to independently confirm this conclusion, I performed a similar hypothetical analysis for a $250,000 policy. I based my work on a Poisson frequency distribution and a log-normal severity distribution. The mean of the medium severity distribution was varied by 50% to generate the low and high severity distributions.

Output from this exercise is displayed in Exhibits I and II. Exhibit I shows the resulting excess loss premium factors. Exhibit II displays the limited insurance charges by severity distribution for the retrospective rating plans selected by Meyers.

This simulated data only partially confirms the author's conclusion. As expected, the limited insurance charges for a given plan are of the same magnitude because fixed charges have been substituted for the most volatile parts of the severity distributions. However, the absolute value of the limited insurance charges generally increases with average severity in this data. This pattern is not as apparent in Exhibit XI in Meyers' paper.

The author also briefly discusses the impact of using a Poisson frequency distribution. While choosing the Poisson distribution because of its widespread use in actuarial literature, he does speculate that the conclusions he reached should hold even if some other distribution were used for the frequency. Exhibit

III displays net insurance charges for a $250,000 policy using a Poisson frequency distribution and a negative binomial frequency distribution with a coefficient of variation ($\sigma/\mu$) of .70. This selection for the coefficient of variation was not based on an empirical study, but was chosen to contrast the Poisson and negative binomial distributions. Higher insurance charges are generated with the negative binomial since the variance is significantly larger than the mean. In the Poisson distribution, the variance equals the mean.

Exhibit IV shows the limited insurance charges by severity distribution generated with the negative binomial frequency distribution. Note that the conclusion that these values are of the same magnitude regardless of the underlying severity distribution still holds. However, these limited insurance charges are greater than their counterparts generated with a Poisson frequency distribution. This stems from the fact that these limited insurance charges are the difference between the net insurance charges and the loss limitation charges. While the net insurance charges vary with the frequency distribution, the loss limitation charges do not, since the excess loss premium factor is a function of the underlying severity distribution only.

Note that the pattern of movement of the limited insurance charges in Exhibit IV is just the opposite of the pattern in Exhibit II. I do not attach any significance to this since the same coefficient of variation was used for the negative binomial frequency distribution in conjunction with each level of severity. One may argue, however, that the coefficient of variation should decrease with decreasing average severity since the expected number of claims increases to achieve $150,000 ($250,000 × .600) of expected losses. The question of the proper frequency distribution to employ should be investigated with actual data.

It appears that Glenn Meyers has gone to a great deal of work in calculating net insurance charges by setting the "retrospective premium adequacy" variable equal to 1.0 and using the Modified Regula Falsi method. However, given insurance charge information by entry ratio, one can solve for the net insurance charge in more traditional fashion.[2] Central to solving for the net insurance charge is the fact that retrospective rating is designed on the average to return the premium discount. Keeping this in mind, one can investigate a host of questions regarding the adequacy of premium generated under retrospective rating plans. The Appendix briefly discusses a few such questions related to the overlap of net insurance charges and loss limitation charges in the current formula.

[2] For two methods, see *Rating Supplement for Workers Compensation and Employers Liability Insurance Retrospective Rating Plan D*, issued by National Council on Compensation Insurance.

Following are two comments for the reader regarding the definition of the basic premium factor found in the paper. The basic premium factor, *b*, is defined as follows:

$$b = a + (c \times i)$$

The factor "*a*" provides for the "acquisition expenses, general underwriting expenses and profit." The loss conversion factor is represented by "*c*" and "*i*" stands for the "insurance charge." Thus, the insurance charge does not include the application of the loss conversion factor. The reader should be aware that definitions of insurance charge usually include the application of the loss conversion factor, contrary to the definition in the body of the paper. Keeping this in mind may help avoid some confusion.

The second comment concerns the definition of the expense portion of the basic premium factor as the provision for expenses other than loss adjustment expenses and taxes. This definition is true only if the selected loss conversion factor is equal to the ratio of losses plus loss adjustment expenses to losses contemplated in the expense table being used. While this definition may be useful as an educational tool for introducing the concept of retrospective rating, it doesn't lead to an appreciation of the flexibility available in the retrospective rating plan D through the interaction of the basic premium factor and the loss conversion factor.

Note that the author's suggested approach to adjusting insurance charge calculations fundamentally differs from the approach explored by Frank Harwayne and David Skurnick.[3] Whereas Harwayne and Skurnick propose the addition of an incremental charge to the Table M charge when a per accident limitation is imposed, Meyers proposes employing a modified insurance charge in addition to the loss limitation charge. In other words, Harwayne and Skurnick propose keeping Table M intact while Meyers proposes keeping the excess loss premium factor intact.

I favor Glenn Meyers' approach. In both approaches, the excess loss premium factor is assumed to be correct for the risk in question. Similarly, the Table M charge is acknowledged to be wrong when used in conjunction with a loss limitation. It therefore makes more sense to retain the excess loss premium factor and modify the insurance charge in attempting to avoid the "ruinous tide of paper."

[3] See the discussions by Frank Harwayne and David Skurnick, *PCAS* LXII, 1975, p. 16.

I hope this paper will convince the reader that further investigations in this area with actual data are warranted. Although modification of the current retrospective rating plan formula will be expensive and time consuming, the resulting increase in pricing equity should be worth the investment. The industry has turned to our profession for some solutions to the problem. It is our responsibility to follow through on leads such as the one presented in this paper.

## EXHIBIT I

### Excess Loss Premium Factors by Severity Distribution

| Loss Limitation | Severity Distribution Low | Medium | High |
|---|---|---|---|
| $ 10,000 | .173 | .304 | .376 |
| 15,000 | .128 | .242 | .310 |
| 20,000 | .111 | .215 | .279 |
| 25,000 | .097 | .193 | .253 |
| 30,000 | .085 | .173 | .230 |
| 35,000 | .075 | .156 | .211 |
| 40,000 | .068 | .143 | .195 |
| 50,000 | .056 | .119 | .169 |
| 75,000 | .039 | .089 | .127 |
| 100,000 | .029 | .069 | .101 |
| 150,000 | .018 | .047 | .070 |
| 200,000 | .013 | .034 | .052 |
| 250,000 | .010 | .026 | .040 |
| 300,000 | .007 | .020 | .032 |
| 500,000 | .003 | .009 | .014 |
| 1,000,000 | .000 | .001 | .002 |

Permissible Loss Ratio = .600

# EXHIBIT II

## LIMITED INSURANCE CHARGES BY SEVERITY DISTRIBUTION

Standard Premium = $250,000
Loss Limitation = $50,000
Poisson Frequency Distribution

| Minimum Premium | Maximum Premium | Limited Insurance Charge: Low Severity | Medium Severity | High Severity |
|---|---|---|---|---|
| BxTM | 1.00 | .037 | .053 | .062 |
| BxTM | 1.20 | .008 | .012 | .016 |
| BxTM | 1.40 | .001 | .003 | .004 |
| BxTM | 1.60 | .000 | .000 | .002 |
| BxTM | 1.80 | .000 | .000 | .000 |
| .60 | 1.00 | .033 | .046 | .054 |
| .60 | 1.20 | .002 | .000 | .000 |
| .60 | 1.40 | −.004 | −.009 | −.013 |
| .60 | 1.60 | −.005 | −.012 | −.017 |
| .60 | 1.80 | −.005 | −.012 | −.017 |

Permissible Loss Ratio = .600
Loss Conversion Factor = 1.125
Tax Multiplier = 1.040

# EXHIBIT III

## NET INSURANCE CHARGES BY FREQUENCY DISTRIBUTION

Standard Premium = \$250,000
Loss Limitation = \$50,000
Medium Severity Risk

| Minimum Premium | Maximum Premium | Net Insurance Charge: Poisson Frequency | Net Insurance Charge: Negative Binomial Frequency* |
|---|---|---|---|
| BxTM | 1.00 | .187 | .298 |
| BxTM | 1.20 | .146 | .217 |
| BxTM | 1.40 | .137 | .180 |
| BxTM | 1.60 | .134 | .161 |
| BxTM | 1.80 | .134 | .151 |
| .60 | 1.00 | .180 | .282 |
| .60 | 1.20 | .134 | .167 |
| .60 | 1.40 | .125 | .119 |
| .60 | 1.60 | .122 | .092 |
| .60 | 1.80 | .122 | .078 |

Permissible Loss Ratio = .600
Loss Conversion Factor = 1.125
Tax Multiplier = 1.040

* Coefficient of variation ($\sigma/\mu$) = .70

# EXHIBIT IV

## Comparison of Limited Insurance Charges by Severity Distribution

Standard Premium = $250,000
Loss Limitation = $50,000
Negative Binomial Frequency Distribution*

| Minimum Premium | Maximum Premium | Limited Insurance Charge<br>Low Severity | Medium Severity | High Severity |
|---|---|---|---|---|
| BxTM | 1.00 | .179 | .164 | .140 |
| BxTM | 1.20 | .088 | .083 | .069 |
| BxTM | 1.40 | .048 | .046 | .036 |
| BxTM | 1.60 | .027 | .027 | .019 |
| BxTM | 1.80 | .015 | .017 | .011 |
| .60 | 1.00 | .152 | .148 | .134 |
| .60 | 1.20 | .029 | .033 | .029 |
| .60 | 1.40 | −.030 | −.015 | −.014 |
| .60 | 1.60 | −.058 | −.042 | −.039 |
| .60 | 1.80 | −.073 | −.056 | −.054 |

Permissible Loss Ratio = .600
Loss Conversion Factor = 1.125
Tax Multiplier = 1.040

* Coefficient of variation ($\sigma/\mu$) = .70

## APPENDIX

This appendix outlines a method to quantify the impact of the overlap of insurance charges and loss limitation charges under the current retrospective rating plan formula. All calculations are performed at the $250,000 standard premium size and a $50,000 loss limitation, with the medium underlying severity distribution as presented in the body of this discussion. It is assumed that the average loss ratio is equal to the permissible loss ratio. The adequacy of premium generated under retrospective rating is measured against the targeted return of stock premium discount (15.5%). This 15.5% reflects the stock premium discounts under the workers compensation expense program effective April 15, 1975. Situations with inadequate insurance charges and inadequate excess loss premium factors are also explored.

These retrospective rating values are constant in all calculations:

Maximum Premium (*MAXPREM*) = 1.20
Minimum Premium (*MINPREM*) = .60
Loss Conversion Factor (*LCF*) = 1.125
Permissible Loss Ratio (*PLR*) = .60
Tax Multiplier (*TM*) = 1.040

The following items vary with the problem being solved:

Excess Loss Premium Factor (*ELPF*)

Basic Premium Factor (*b*)

Maximum Loss Ratio′ (*MAXLR′*): The loss ratio at the Maximum Premium if a loss limitation charge (*ELPF* × *LCF*) is used.

Minimum Loss Ratio′ (*MINLR′*): The loss ratio at the Minimum Premium if a loss limitation charge (*ELPF* × *LCF*) is used.

X′: The actual charge needed at the *MAXLR′*. Reflects the impact of the loss limitation charge.

S′: The actual savings realized at the *MINLR′*. Reflects the impact of the loss limitation charge.

Equations used to solve the problems:

(1): $MAXPREM = [b + ELPF \times LCF + MAXLR' \times LCF] \times (TM)$

(2): $MINPREM = [b + ELPF \times LCF + MINLR' \times LCF] \times (TM)$

(3): Average Retro Premium $= [b + ELPF \times LCF + (1.0 - X' + S') \times (PLR) \times (LCF)] \times (TM)$

Average Retro Premiums are calculated in the following situations with the current retrospective rating plan formula:

| Situation | Net Insurance Charge | Loss Limitation Charge |
|---|---|---|
| A | Adequate | Adequate |
| B | Adequate | 50% Inadequate |
| C | 50% Inadequate | 50% Inadequate |

| Item | Situation | | |
|---|---|---|---|
| | A | B | C |
| $b$ | .212 | .212 | .173 |
| $ELPF \times LCF$ | .134 | .067 | .067 |
| $MAXLR'$ | .718 | .778 | .812 |
| $MINLR'$ | .205 | .265 | .300 |
| $X'$ | .227 | .217 | .213 |
| $S'$ | .004 | .013 | .023 |
| Average Retro Premium | .905 | .850 | .818 |

The average retro premiums should be compared to the targeted retro premium of .845 (1.0 − .155). In situation A, one sees that the impact of the overlap can be very significant if insurance charges and excess loss premium factors are both adequate. In situation B, the targeted return is almost achieved due to the inadequate loss limitation charge offsetting the overlap. Situation C indicates a 3 percent net premium deficiency (.818 ÷ .845 = .968) when both the net insurance charge and the loss limitation charge are 50 percent inadequate.

This technique is particularly useful in investigating the impact of retrospective rating under various assumptions regarding average loss ratios and insurance charge adequacy. Of course, it isn't necessary to include a loss limitation in the calculation or assume that the average loss ratio is equal to the permissible loss ratio.