Expected Loss Development: A Shift in Credibility

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This paper is a commentary on the previously published paper "Partial Loss Development Based On Expected Losses For Workers' Compensation Class Ratemaking", Casualty Actuarial Society Forum. Special Edition. 1993 Ratemaking Call Papers.

This paper shows that expected loss development is equivalent to adjusting the full credibility standard and applying credibility by policy period.

Expected Loss Development: A Shift in Credibility

Concerns with the current loss development method used in Workers' Compensation class ratemaking have been raised. If a class has zero losses at a first report, using a first to ultimate loss development factor produces zero ultimate losses as well. One possible solution that has been proposed is to use expected loss development. To simplify the illustration, assume that all losses are at the same benefit level etc., so as to only look at loss development. The other factors can easily be taken into account later. Also for simplicity assume that there is only one policy period used and national pure premiums are not used. The following arguments will then be extended to include more policy periods and the use of national pure premiums.

Workers' compensation classification ratemaking relies on several estimates of class pure premiums. One estimate is based on the latest available data for the class and state. This is called the indicated pure premium. Another estimate is the pure premium underlying current rates brought up to the level of the indicated pure premiums. This estimate is called the present on rate level pure premium. A third estimate is a national pure premium which includes data from other states adjusted to reflect conditions in the reviewed state. A formula pure premium to be used in calculating rates, is obtained by credibility weighting these estimates.

Here is a brief description of expected loss development. Initially, expected losses E (present on rate level pure premium times payroll in hundreds) is the estimate of ultimate losses used to calculate the indicated pure premium. At a first report the actual losses A which have emerged at that point can replace the losses that were expected to have emerged by then, namely $(1/D)E$, where D is the first to ultimate loss development factor. This method relies less on actual losses and more on expected losses than the current method. It is important to note that if the development factor is less than one, the estimate of ultimate, losses might be negative.

Credibility weighting produces the losses used in the formula pure premium:

Expected Loss Development: Losses used in Formula Pure Premium

$$Z[A+(1-\frac{1}{D})E] + (1-Z)E$$

$$= ZA + ZE - \frac{Z}{D}E + E - ZE$$

$$= ZA - \frac{Z}{D}E + E$$

$$= \frac{Z}{D} AD + \left(1 - \frac{Z}{D}\right) E$$

Current Method: Losses used in Formula Pure Premium

$$ZAD + (1 - Z) E$$

These two formulas are equivalent where Z/D is substituted for Z. Using Z/D instead of Z is equivalent to changing the full credibility standard which already limits fluctuations of formula pure premiums to a desired amount. For example. if $Z=(n/n_f)^{1/2}$ and $D=3$, then $Z/D=(n/9n_f)^{1/2}$. The expected loss development method implicitly lowers credibility by $1/D$, when D> 1. Expected loss development is a shift in credibility, giving less weight to actual losses and more weight to expected losses.

The equation which shows that expected loss development is equivalent to changing the full credibility standard can be expanded to include more policy periods and the use of national pure premiums. The relationship holds if the credibility of indicated data is calculated by policy period and the national credibility is allowed to remain unchanged as one switches from one method to the other.

Attached is a detailed algebraic proof of the equivalence relationship (Attachment 1). The proof shows that the serious (or nonserious or medical) formula pure premium calculated using expected loss development is equal to the serious (or nonserious or medical) formula pure premium calculated by using credibility by policy period. where the credibility one would normally use is divided by the policy period's development to ultimate factor and multiplied by a factor reflecting the contribution of the policy period's exposure to the total. These individual credibilities are then used as weights for the indicted pure premiums calculated separately for each individual policy period.

Also attached is a specific illustration (Attachment 2) of the equivalence relationship which uses the example from exhibit 1 of the paper "Partial Loss Development Based On Expected Losses For Workers' Compensation Class Ratemaking". Casualty Actuarial Society Forum. Special Edition. 1993 Ratemakine Call Papers, as well as the development factors listed in the paper on page 321 (See attachment 3). Note that, as a separate issue, the state credibilities in the paper are calculated using a square root rule instead of NCCI's old two thirds rule so that the serious state credibility of .67 is equal to .59 to the three fourths power $[.67=(.59^{3/2})^{1/2}]$.

The illustration focuses on the calculation of the serious formula pure premium. More recent years have higher development factors so credibility is lowered more for them. This could be considered a reliability factor. Each year's credibility also gets multiplied by a weight equal to the year's proportion of exposure to the total of all years. This could be considered a relevance factor since more recent years would tend to have higher exposures due to wage inflation, all else being constant.

Expected loss development can be thought of as a shift in credibility from the indicated pure premiums to the present on rate level pure premium (See table below). Note that expected loss development relies heavily on the present on rate level pure premium to the extent that the indicated is not considered credible, whereas the new NCCI full credibility standard and partial credibility formula give equal weight to the present on rate level pure premium and the national pure premium.

NCCI now uses higher full credibility standards and a .4 power partial credibility formula to recognize the need for stability. Note that the credibility given to the indicated data using the new NCCI standard and formula is about the same as the credibility for expected loss development, therefore limiting fluctuations by about the same amount as expected loss development, An advantage to the expected loss development scheme is the consideration of different credibilities by policy period.

Credibilities - Class 7600

Serious Pure Prem	Indicated	National	PORL
Current Loss Development	.67	.16	.17
Expected Loss Development	.33	.16	.51
New NCCI Standard And Formula	.38	.31	.31

A_1 = **actual** first report losses, A_2 = **second** report, A_3 = **third** report
D_1 = **first** to ultimate loss development factor, D_2 = **second** to ultimate, D_3 = **third** to ultimate
E_1 = **ultimate** expected losses for **first** report, E_2 = **second** report, E_3 = **third** report
$E = E_1 + E_2 + E_3$
P_1 = **first** report payroll in hundreds, P_2 = **second** report, P_3 = **third report**
$P = P_1 + P_2 + P_3$
Z = state indicated credibility
Z_n = **national** credibility
N/P = **national** pure premium
E/P = present on rate level pure premium
$E_1 = (E/P)P_1$, $E_2 = (E/P)P_2$, $E_3 = (E/P)P_3$

Expected Loss Development: Formula Pure Premium

$$Z\left[\frac{(A_1+(1-\frac{1}{D_1})E_1)+(A_2+(1-\frac{1}{D_2})E_2)+(A_3+(1-\frac{1}{D_3})E_3)}{P}\right]+(1-Z-Z_n)\left[\frac{E}{P}\right]+Z_n\left[\frac{N}{P}\right]$$

$$=\frac{Z(A_1+A_2+A_3)+Z(E_1+E_2+E_3)-\frac{Z}{D_1}E_1-\frac{Z}{D_2}E_2-\frac{Z}{D_3}E_3+E-ZE-Z_nE+Z_nN}{P}$$

$$=\frac{\frac{Z}{D_1}A_1D_1+\frac{Z}{D_2}A_2D_2+\frac{Z}{D_3}A_3D_3+ZE-\frac{Z}{D_1}E_1-\frac{Z}{D_2}E_2-\frac{Z}{D_3}E_3+(E_1+E_2+E_3)-ZE-Z_nE+Z_nN}{P}$$

$$=\frac{[\frac{Z}{D_1}A_1D_1+(1-\frac{Z}{D_1})E_1]+[\frac{Z}{D_2}A_2D_2+(1-\frac{Z}{D_2})E_2]+[\frac{Z}{D_3}A_3D_3+(1-\frac{Z}{D_3})E_3]-Z_nE+Z_nN}{P}$$

$$=\left(\frac{Z}{D_1}\right)\left(\frac{P_1}{P}\frac{A_1D_1}{P_1}\right)+\left(\frac{Z}{D_2}\right)\left(\frac{P_2}{P}\frac{A_2D_2}{P_2}\right)+\left(\frac{Z}{D_3}\right)\left(\frac{P_3}{P}\frac{A_3D_3}{P_3}\right)$$

$$+\left[\left(1-\frac{Z}{D_1}\right)\frac{P_1}{P}+\left(1-\frac{Z}{D_2}\right)\frac{P_2}{P}+\left(1-\frac{Z}{D_3}\right)\frac{P_3}{P}\right]\left(\frac{E}{P}\right)-Z_n\left(\frac{E}{P}\right)+Z_n\left(\frac{N}{P}\right)$$

$$= \left(\frac{Z}{D_1}\frac{P_1}{P}\right)\left(\frac{A_1D_1}{P_1}\right) + \left(\frac{Z}{D_2}\frac{P_2}{P}\right)\left(\frac{A_2D_2}{P_2}\right) + \left(\frac{Z}{D_3}\frac{P_3}{P}\right)\left(\frac{A_3D_3}{P_3}\right)$$

$$+ \left[1 - \left(\frac{Z}{D_1}\frac{P_1}{P}\right) - \left(\frac{Z}{D_2}\frac{P_2}{P}\right) - \left(\frac{Z}{D_3}\frac{P_3}{P}\right) - Z_n\right]\left(\frac{E}{P}\right) + Z_n\left(\frac{N}{P}\right)$$

Current Method: Formula Pure Premium

$$Z\left[\frac{A_1D_1 + A_2D_2 + A_3D_3}{P}\right] + (1 - Z - Z_n)\left[\frac{E}{P}\right] + Z_n\left[\frac{N}{P}\right]$$

Serious pure premium - class 7600

$$\underset{\text{3rd-ult dev}}{\overset{\text{st cred}}{\frac{0.67}{1.417}}} * \underset{\text{total pay}}{\overset{\text{3rd rpt pay}}{\frac{42{,}616{,}748}{135{,}892{,}859}}} = \overset{\text{3rd rpt cred}}{0.15} \qquad \underset{\text{3rd rpt pay}}{\overset{\text{3rd rpt dev loss}}{\frac{393{,}906}{42{,}616{,}748/100}}} = \overset{\text{3rd rpt ind pp}}{0.924}$$

$$\underset{\text{2nd-ult dev}}{\overset{\text{st cred}}{\frac{0.67}{1.993}}} * \underset{\text{total pay}}{\overset{\text{2nd rpt pay}}{\frac{49.728.462}{135{,}892{,}859}}} = \overset{\text{2nd rpt cred}}{0.12} \qquad \underset{\text{2nd rpt pay}}{\overset{\text{2nd rpt dev loss}}{\frac{145{,}463}{49{,}728{,}462/100}}} = \overset{\text{2nd rpt ind pp}}{0.293}$$

$$\underset{\text{1st-ult dev}}{\overset{\text{st cred}}{\frac{0.67}{3.773}}} * \underset{\text{total pay}}{\overset{\text{1st rpt pay}}{\frac{43{,}547{,}649}{135{,}892{,}859}}} = \overset{\text{1st rpt cred}}{0.06} \qquad \underset{\text{1st rpt pay}}{\overset{\text{1st rpt dev loss}}{\frac{1{,}731{,}862}{43{,}547{,}649/100}}} = \overset{\text{1st rpt ind pp}}{3.977}$$

nat cred	nat pure prem
0.16	1.287

remaining cred	porl pure prem
0.51	1.203

$$0.15*0.924+0.12*0.293+0.06*3.977+0.16*1.287+0.51*1.203= \overset{\text{form pure prem}}{1.221}$$

(float from the start to eliminate rounding difference)

Attachment 3

EXHIBIT 1

COMPUTATION OF REVISED PURE PREMIUM RATE
with loss development based on expected losses

Overall Revision
6.2%

All Other Industry Group

Class: 7600 Telephone or Telegraph Co: All Other Employees & Dvrs

		Displayed Losses			Undeveloped Losses			Revised Losses		
	Payroll	Serious	Non-Ser	Medical	Serious	Non-Ser	Medical	Serious	Non-Ser	Medical
3-year	0	0	0	0	0	0	0	0	0	0
1984	42616748	393906	280841	500903	277986	281969	418465	428859	280879	505647
1985	49728482	145463	252282	480542	72987	254830	356485	371053	251631	516060
1986	43547649	1731882	237862	481927	459015	247258	308532	844044	236300	503288
	135892859	2271231	770985	1463372				1643956	768810	1524995

	NAT'L COUNCIL PROCEDURE				REVISED PROCEDURE		
	Serious	Non-Ser	Medical		Serious	Non-Ser	Medical
	1.671	0.567	1.077	Indicated Pure Premiums	1.210	0.566	1.122
	1.203	0.637	1.243	P.P. "Present on Rate Level"			
	1.287	0.917	1.769	P.P. "Ind. by Nat'l Reltvty"			
	0.59 *	0.78	1.00	State Credibility	0.67	0.83	1.00
Total	0.20	0.11	0.00	National Credibility	0.16	0.08	0.00
3.19	1.496	0.613	1.077	Formula Pure Premium	1.221	0.600	1.122
	1.008	1.008	1.008	Composite Factor			
	1.007	1.004	1.000	Effect of Benefit Change			
	1.092	1.092	0.975	Change in Trend Factor			
		3.39		Rounded Total		3.12	
		1.007		Ratio of Manual to Earned Premium		1.007	
		1.000		Contracting Prem Adj Program Offset		1.000	
				Specific Disease Loading			
		3.41		Calculated Pure Premium Rate		3.14	
Swing		2.86		Current Pure Premium Rate		2.86	
Limits:							
33%	above	3.41		Swing-Limited Pure Premium Rate		3.14	
14%	below	19.2%		Percentage Change		9.8%	
				Difference from Nat'l Council		-7.9%	

$*(.59)^{3/4} = .67$

330

performed for this paper. The revisions for 1991 and 1992 use differing pure premium input data for the two development methods so separate worksheets were needed.

The rate revisions for Class 7600 in Exhibit 1 achieve materially different results and also illustrate the enhanced credibility formula used with the revised procedure. The NCCI credibility formula is the two-thirds root of the ratio of partial expected losses to the 100 percent standard. The Revised Procedure uses a simple square root formula (or a three-fourths root of the NCCI credibility).

The only other difference is the provision for loss development. The NCCI rate filing for 1990 displayed these loss development factors in Appendix B-I:

Policy Period	Indemnity Serious	Indemnity Non-Serious	Medical
1984	1.417	.996	1.197
1985	1.993	.990	1.348
1986	1.773	.962	1.562
Three-Year Fixed	2.394	.983	1.369

Exhibit 1 shows the payroll and losses as they would be shown in the National Council filing Appendix B-II. The losses have been developed and adjusted to current benefits, trends, and accident-year experience. The revised model simply divides these displayed losses by the partial loss development