THE CASH FLOW OF A RETROSPECTIVE RATING PLAN

by

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Abstract

With current methodology, the parameters of a retrospective rating plan are calculated to place the plan in balance on an underwriting basis. This paper provides a way of calculating the present value of the retrospective premium. Using this methodology, one can compare the expected profitability of various retrospective rating plans on a dicounted or operating basis. This includes paid loss retros. It is also possible to determine the parameters of a plan that will yield a predetermined operating profit.

1. Introduction

In recent years, the state of the property and casualty insurance industry could be characterized by three highs: high combined ratios; high interest rates; and a high degree of competition. Insurance company managers know that a great deal of investment income can be made by writing insurance, and they are willing to lower prices in order to do this.

The question to be asked, then, is how much can rates be lowered in order to still maintain an acceptable overall profit? It should be noted that in practice, actuaries do not have complete control of the pricing process. Underwriting and marketing personnel have considerable input. If actuaries do not calculate the contribution of investment income to the profitability of a line of insurance, someone else will. And the resulting "calculation" may amount to no more than a reaction to competitive pressures.

The question is not whether to use investment income in the calulation of rates. Instead the question is how to use investment income in the calculation of rates.

This paper considers the effect of investment income in choosing the parameters of a retrospective rating plan. With current methodology, the parameters of a retrospective rating plan are chosen to place the plan in balance on a nominal, or underwriting basis. By this we mean that the

expected retrospective premium is equal to the sum of the losses, expenses and the anticipated profit. However it is possible for different plans to have the same expected premium and have different cash flows.

For example, a plan with a no maximum will have premium flowing in as long as losses develop, while a plan with a low maximum will stop producing premium as the insured breaks the maximum. Not all insureds will break the maximum, but there will, on average, be a faster premium flow because of the higher basic and the increased number of insureds who do break the maximum.

Other factors, such as the loss conversion factor and the minimum premium factor will also affect the cash flow of a retrospective rating plan.

This paper will provide a way of calculating the present value of the retrospective premium. Using this methodology, one can compare the profitability of various retrospective rating plans on a discounted or operating basis. This includes paid loss retros. It is also possible to calculate parameters of a plan that will yield a predetermined operating profit.

The principal tool used will be the collective risk model. Excess pure premiums will be calculated for the insured at various stages of development. One can then calculate the expected retrospective premium at each stage, and obtain the present value of the retrospective premium.

This technique will enable the insurer to offer a standard incurred loss retro which is competitive with a paid loss retro. This could help relieve some of the pressure that the Internal Revenue Service is putting on paid loss retros. In addition it will become possible to properly price a retro with loss development factors. This will minimize the size of retrospective adjustments as time passes.

We begin by first defining the parameters of a retrospective rating plan.

2. The Parameters Defined

The retrospective premium, R, for an insured is given by the following formula[1].

$$R = (B + c \cdot E + c \cdot L) \cdot t$$

R is subject to a maximum of G and a minimum of H.

B is the basic premium. Traditionally B covers general expenses, profit and the insurance charge (i.e. the net cost of the minimum and maximum premium provisions). There is no particular reason why B has to be set equal to these cost provisions. In its pure form, B is simply an amount that is used to determine the retrospective premium.

The factor c is called the loss conversion factor. Traditionally c covers the loss adjustment expenses. Again, there is no reason why it has to be set equal to a loss adjustment factor. In its pure form, c is simply a factor used to determine the retrospective premium.

Many retrospective rating plans provide that no claim amount over a specified loss limit shall be used to calculate the retrospective premium. In this case, the expected loss resulting from this provision must be added to the retrospective premium. This amount is denoted by E.

L represents the actual losses incurred under the plan.

Premium taxes are provided for by the factor t.

In order to keep this paper as simple as possible, we will not consider the effect of loss limits and premium taxes until the end of the paper. We shall also ignore the minimum premium. This results in a simplified formula for the retrospective premium.

$$R = B + c \cdot L$$

subject to the maximum, G.

The timing of the retrospective premium payments is of particular importance. Recall that some claims are open a long time before final settlement. Thus incurred losses are necessarily estimates of the final claims costs. Experience has shown these estimates are usually low, and so one should expect the retrospective premium to increase over time. The first calculation is based on losses reported eighteen months after the effective date of the policy. Subsequent calculations are performed on a yearly basis. Payments typically lag three months behind the retrospective premium calculations.

It is usually required to make some sort of premium payment before the first retrospective adjustment. Traditionally, this payment has been equal to the standard premium due on the effective date of the policy. More recently, the trend

has been to pay an amount totaling less than the standard premium in installments.

We will be following a single hypothetical insured throughout this paper. The loss and expense information for this insured is given in the following table.

Table 1

	Nominal	Present Value at 8%
Expected Incurred Losses	1000000	820000
Expected Loss Adj. Exp.	100000	87000
Other Expenses	57500	55000
Total	1157500	962000

The expected incurred losses for each retrospective adjustment period are given in the following table.

Table 2

Retrospective Adjustment	Expected Incurred Losses
#1 @ 18 months	833333
#2 @ 30 months	946970
#3 @ 42 months	975610
#4 @ 54 months	986193
#5 @ 66 months	991080
#6 @ 78 months	996016
#7 @ 90 months	1000000

In order to calculate the average retrospective premium, one needs to have tables of excess pure premiums which correspond to each retrospective adjustment. These tables are provided in Exhibit I. The Heckman-Meyers algorithm[2] was used to generate these tables. While the input for this algorithm could be provided, it seems just as easy to assume the tables are given.

These tables provide excess pure premiums for loss amounts in increments of 10000. Linear interpolation can be used to calculate excess pure premiums for loss amounts that are not a multiple of 10000.

The average retrospective premium is calculated in the following manner[3]. Define the effective maximum to be equal to (G - B)/c, and let X be the excess pure premium for losses over the effective maximum. Then the average retrospective premium is given by:

$$E[R] = B + c*(E[L] - X).$$

As an example, assume B = 232450, G = 1500000, c = 1.1, and E[L] = 1000000. Then the effective maximum = 1152320. By linear interpolation on Exhibit I (90 months), we find X = 131775, and E[R] = 1187500.

3. The Standard Incurred Loss Retro

We first calculate the expected underwriting profit for a standard incurred loss retro. We need only consider the seventh (final) retrospective adjustment for this calculation.

Table 3

Basic	232450
l.c.f.	1.1
Maximum	1500000
E[R] @ 90 mths.	1187500
Loss & Expense	1157500
Underwriting Profit	30000

This plan was designed to yield approximately the 2.5% underwriting profit that is budgeted in standard Workers' Compensation rate filings.

Next we calculate the expected operating profit for the same plan assuming an effective annual interest rate of 8%. That is to say, for example, that a payment due in three months is discounted at a rate of $1.08^{-0.25}$. A deposit premium of 960000 is to be payable in six quarterly installments of 160000. The present value of the deposit premium is 915410. Additional amounts of premium due to retrospective adjustments are assumed to be paid three months after the calculation of the retrospective premium.

Table 4

Basic	232450
l.c.f.	1.1
Maximum	1500000
Deposit	960000
E[R] @ 18 mths.	1078380
@ 30 mths.	1155720
@ 42 mths.	1173210
@ 54 mths.	1179480
@ 66 mths.	1182340
@ 78 mths.	1185200
@ 90 mths.	1187500
P.V. Retro Premium	1103720
P.V. Loss & Expense	962000
Operating Profit	141720

In this example we see that the standard rating method yields an operating profit of nearly 12% of the ultimate average retrospective premium. This is fine if the competition will allow it. If not, the insurance company management must decide what operating profit to seek.

Suppose they decide to seek an operating profit of 100000. Perhaps there is a vague notion that an underwriting profit of 30000 already anticipates a certain amount of investment income, and is not appropriate for an operating profit. Anyway, the question becomes one of selecting the basic premium that yields the desired operating profit. This can be done by repeating the calculations of Table 4 on a trial and error basis, although a numerical method may yield the desired solution more quickly[4]. The results of this process are in the following Table.

Table 5

Basic	167150
l.c.f.	1.1
Maximum	1500000
Deposit	960000
E[R] @ 18 mths.	1024100
@ 30 mths.	1106410
@ 42 mths.	1125210
@ 54 mths.	1131970
@ 66 mths.	1135050
@ 78 mths.	1138140
@ 90 mths.	1140620
P.V. Retro Premium	1062000
P.V. Loss & Expense	962000
Operating Profit	100000

Having demonstrated how to select the basic premium which yields a predetermined operating profit, it should be pointed out that it is possible to fix the basic premium and select the loss conversion factor which yields a predetermined operating profit.

Certain other cash flow provisions of a retrospective rating plan are often subject to negotiation between insurer and insured. Thus it seems appropriate that we show how to properly account for them.

4. Retro Development Factors

An optional provision of most retrospective rating plans is to adjust the incurred losses to their ultimate value by means of a loss (or retro) development factor. An advantage to the insured is that the retrospective premium is close to its ultimate value at the first retrospective adjustment. A disadvantage is that the insured must pay the premium sooner. To overcome this disadvantage, the insurer can offer to lower either the basic premium or the loss conversion factor.

In the following table we consider the latter option. The deposit premium is to be paid in installments as before. Although several retrospective adjustments are made, the contribution of the later adjustments is assumed to be negligible. The final table of excess pure premiums (evaluated at 90 months) was used to calculate the average retrospective premium at the first adjustment.

Table 6

Basic	167150
l.c.f.	1.0775
Maximum	1500000
Deposit	960000
E[R] @ 18 mths.	1127730
P.V. Retro Premium	1062000
P.V. Loss & Expense	962000
Operating Profit	100000

The results of this calculation should be directly comparable with the previous calculation (Table 5). The introduction of retro development factors caused about a

1.1% decrease in the average retrospective premium on a nominal basis.

The accuracy of this calculation depends upon our ability to calculate the proper loss development factors. Even if we get the correct overall loss development factors, changes in the shape of the aggregate loss distribution over time will affect the average retrospective premium. The author suspects that the result, over time, will be a thicker tail for the aggregate loss distribution, a higher excess pure premium and a slight decrease in the average retrospective premium. Losses which are revalued upward will be limited by the maximum premium, while losses which are valued downward will be unaffected. A full treatment of this effect is beyond the scope of this paper.

5. Paid Loss Retros

A very popular rating plan in recent years has been the so called "paid loss retro." While the details of the financial transactions may vary, a typical plan could work as follows. A basic premium is paid, possibly in installments. The retrospective premium based on paid losses is continuously paid from a special fund set up by the insured. At some point in time, usually 54 months after the effective date, the plan switches over to an ordinary incurred loss retro.

The continuous adjustment of the retrospective premium presents a technical problem. There is always the possibility that the insured will break the maximum on paid losses before the 54 month switchover. This could, in theory, require daily tables of excess pure premiums. In practice, the possibility of breaking the maximium before the switchover is considered remote, and is ignored in the following calculations. The average retrospective premium can then be estimated using ordinary loss payout patterns.

The effect of this simplifying assumption would be to overstate the average retrospective premium before the switchover. It will be corrected at the 54 month adjustment. The end result will be to overstate the present value of the average retrospective premium by the amount of interest earned on the excess pure premium before the switchover. This should be a negligibile amount.

Let us assume that our hypothetical insured is expected to have paid 800000 in losses by the switchover time, and that the present value of these payments is 720000. Let us also assume that the basic premium is paid on the effective date of the plan. The following table describes the plan in detail.

Table 7

Basic	215170
l.c.f.	1.1
Maximum	1500000
E[Paid R]	1095170
E[R] @ 54 mths.	1167130
@ 66 mths.	1170050
@ 78 mths.	1172980
@ 90 mths.	1175320
P.V. E[Paid R]	1007170
P.V. Retro Premium	1062000
P.V. Loss & Expense	962000
Operating Profit	100000

The results of this calculation should be directly comparable to the straight incurred loss retro (Table 5). The paid loss provision caused about a 3% increase in the average retrospective premium on a nominal basis.

5. Excess Loss Premium and Tax Multiplier

We did not consider the excess loss premium or the tax multiplier in the above calculations. The intent was to keep the discussion as simple as possible. We now show how to modify the calculation to take these into account.

On the premium side of the calculation, the only adjustment needed to handle the loss limit is to input a limited claim severity distribution into the Heckman-Meyers algorithm. No adjustment is needed on the loss and expense side. Make note that the present value of the unlimited losses is still used.

A wrinkle in the above adjustment occurs when the excess layer is reinsured and one wants to incorporate the cost of reinsurance in the pricing. In this case one takes the sum of the present value of the limited losses, and the cost of the reinsurance. This sum is used in place of the present value of the unlimited losses. A note of caution: the payout pattern for limited losses is faster than that of unlimited losses.

Premium taxes are paid on the basis of written premium. One should note that retrospective adjustments are also adjustments in written premium. The present value of the premium taxes can be calculated by using the average retrospective premium at each adjustment.

The following question should be asked at this point. Do we really need to have separate factors in the retrospective rating plan for excess losses and premium taxes?

Tax multipliers are not used in guaranteed cost plans, so why use them for retrospective rating? Rates for other guaranteed cost plans reflect premium taxes, and so could the basic premium and the loss conversion factor.

Skurnick[5] put the excess premium into the basic premium for the California Table L, and there is no reason why this could not be done for all retrospective rating plans.

What really matters is that the present value of the retrospective premium is equal to the profit plus the present value of the losses and expenses. This can be accomplished by a proper selection of the basic premium and the loss conversion factor. The result will be a simpler formula for retrospective rating.

6. Conclusion

This paper is written under the premise that an explicit calculation of investment income is superior to the implicit recognition of investment income that some say is in many present rating formulas. We do not attempt to determine the proper operating profit. This task belongs to insurance company management and/or regulators. It does not belong to some ratemaking formula based on underwriting profit.

We have provided a methodology for finding the expected operating profit for a retrospective rating plan. This methodology is presently in use at a major insurance company.

The author suspects that the more complicated versions of retrospective rating, such as paid loss retros, arose because the present plan does not allow for investment income. Now that the various versions of retrospective rating can be rated on a comparable basis, it is hoped that the more complicated versions will no longer be necessary. Retrospective rating can be made simple.

7. Acknowledgments.

This paper is an outgrowth of a project which I directed during my final year at CNA Insurance Companies. I worked very closely with John Meeks and Steve Maguire in developing the conceptual basis for what we called the "Account Pricing System." Steve and Ron Swanstrom wrote a program which made these ideas very workable in a production environment.

Exhibit I - Excess Pure Premiums

LOSSES VALUED AT 18 MONTHS EXPECTED LOSSES = 833333			LOSSES VALUED AT 30 MONTHS EXPECTED LOSSES = 946970		
LOSS AMOUNT	CUMULATIVE PROBABILITY	EXCESS PURE PREMIUM	LOSS AMOUNT	CUMULATIVE PROBABILITY	EXCESS PURE PREMIUM
900000	0.6508	129345	900000	0.5469	196000
910000	0.6594	125896	910000	0.5561	191516
920000	0.6678	122532	920000	0.5653	187123
930000	0.6760	119251	930000	0.5742	182820
940000	0.6840	116051	940000	0.5831	178607
950000	0.6919	112930	950000	0.5918	174481
960000	0.6996	109887	960000	0.6003	170442
970000	0.7071	106920	970000	0.6088	166487
980000	0.7144	104028	980000	0.6170	162616
990000	0.7216	101208	990000	0.6252	158827
1000000	0.7286	98459	1000000	0.6332	155119
1010000	0.7355	95780	1010000	0.6410	151490
1020000	0.7422	93168	1020000	0.6487	147939
1030000	0.7488	90623	1030000	0.6563	144464
1040000	0.7552	88143	1040000	0.6638	141064
1050000	0.7614	85726	1050000	0.6711	137739
1060000	0.7675	83371	1060000	0.6782	134485
1070000	0.7735	81076	1070000	0.6853	131303
1080000	0.7793	78840	1080000	0.6922	128190
1090000	0.7850	76662	1090000	0.6989	125145
1100000	0.7906	74540	1100000	0.7056	122168
1110000	0.7960	72473	1110000	0.7121	119256
1120000	0.8013	70459	1120000	0.7185	116409
1130000	0.8065	68498	1130000	0.7247	113625
1140000	0.8115	66588	1140000	0.7309	110903
1150000	0.8165	64728	1150000	0.7369	108241
1160000	0.8213	62917	1160000	0.7427	105639
1170000	0.8260	61153	1170000	0.7485	103095
1180000	0.8306	59435	1180000	0.7542	100609
1190000	0.8350	57763	1190000	0.7597	98178
1200000	0.8394	56135	1200000	0.7651	95802
1210000	0.8436	54550	1210000	0.7704	93479
1220000	0.8478	53007	1220000	0.7756	91209
1230000	0.8519	51505	1230000	0.7807	88991
1240000	0.8558	50043	1240000	0.7857	86823
1250000	0.8597	48620	1250000	0.7906	84704
1260000	0.8634	47235	1260000	0.7954	82634
1270000	0.8671	45887	1270000	0.8001	80611
1280000	0.8707	44576	1280000	0.8046	78635
1290000	0.8742	43300	1290000	0.8091	76703
1300000	0.8776	42058	1300000	0.8135	74816

Exhibit I - Excess Pure Premiums

LOSSES VALUED AT 42 MONTHS EXPECTED LOSSES = 975610			LOSSES VALUED AT 54 MONTHS EXPECTED LOSSES = 986193		
LOSS AMOUNT	CUMULATIVE PROBABILITY	EXCESS PURE PREMIUM	LOSS AMOUNT	CUMULATIVE PROBABILITY	EXCESS PURE PREMIUM
900000	0.5218	214600	900000	0.5127	221641
910000	0.5311	209865	910000	0.5221	216815
920000	0.5403	205223	920000	0.5313	212081
930000	0.5494	200672	930000	0.5404	207440
940000	0.5584	196210	940000	0.5493	202888
950000	0.5672	191838	950000	0.5582	198426
960000	0.5759	187553	960000	0.5669	194051
970000	0.5844	183355	970000	0.5755	189763
980000	0.5928	179241	980000	0.5840	185560
990000	0.6011	175211	990000	0.5923	181442
1000000	0.6093	171263	1000000	0.6005	177406
1010000	0.6173	167396	1010000	0.6086	173452
1020000	0.6252	163608	1020000	0.6166	169578
1030000	0.6330	159899	1030000	0.6244	165782
1040000	0.6406	156267	1040000	0.6321	162065
1050000	0.6481	152711	1050000	0.6397	158423
1060000	0.6555	149229	1060000	0.6471	154857
1070000	0.6627	145820	1070000	0.6544	151365
1080000	0.6698	142483	1080000	0.6616	147945
1090000	0.6768	139216	1090000	0.6686	144596
1100000	0.6837	136019	1100000	0.6756	141317
1110000	0.6904	132889	1110000	0.6824	138106
1120000	0.6970	129826	1120000	0.6891	134963
1130000	0.7035	126829	1130000	0.6956	131887
1140000	0.7099	123895	1140000	0.7021	128875
1150000	0.7161	121025	1150000	0.7084	125927
1160000	0.7222	118216	1160000	0.7146	123042
1170000	0.7282	115468	1170000	0.7207	120218
1180000	0.7341	112779	1180000	0.7266	117454
1190000	0.7399	110149	1190000	0.7325	114749
1200000	0.7455	107576	1200000	0.7382	112103
1210000	0.7511	105058	1210000	0.7438	109513
1220000	0.7565	102596	1220000	0.7494	106978
1230000	0.7618	100188	1230000	0.7548	104499
1240000	0.7670	97832	1240000	0.7601	102073
1250000	0.7722	95528	1250000	0.7653	99700
1260000	0.7772	93274	1260000	0.7704	97378
1270000	0.7821	91070	1270000	0.7754	95106
1280000	0.7869	88915	1280000	0.7803	92884
1290000	0.7916	86808	1290000	0.7851	90711
1300000	0.7962	84747	1300000	0.7898	88585

Exhibit I - Excess Pure Premiums

LOSSES VALUED AT 66 MONTHS EXPECTED LOSSES = 991080			LOSSES VALUED AT 78 MONTHS EXPECTED LOSSES = 996016		
LOSS AMOUNT	CUMULATIVE PROBABILITY	EXCESS PURE PREMIUM	LOSS AMOUNT	CUMULATIVE PROBABILITY	EXCESS PURE PREMIUM
900000	0.5086	224922	900000	0.5044	228254
910000	0.5179	220054	910000	0.5137	223345
920000	0.5271	215279	920000	0.5229	218528
930000	0.5362	210595	930000	0.5320	213803
940000	0.5452	206002	940000	0.5410	209168
950000	0.5540	201499	950000	0.5499	204622
960000	0.5628	197083	960000	0.5586	200165
970000	0.5714	192754	970000	0.5673	195795
980000	0.5799	188510	980000	0.5758	191510
990000	0.5883	184351	990000	0.5842	187310
1000000	0.5965	180275	1000000	0.5924	183193
1010000	0.6046	176280	1010000	0.6006	179158
1020000	0.6126	172366	1020000	0.6086	175203
1030000	0.6204	168531	1030000	0.6164	171328
1040000	0.6282	164774	1040000	0.6242	167532
1050000	0.6358	161094	1050000	0.6318	163812
1060000	0.6432	157489	1060000	0.6393	160167
1070000	0.6506	153957	1070000	0.6467	156597
1080000	0.6578	150499	1080000	0.6539	153100
1090000	0.6649	147112	1090000	0.6611	149675
1100000	0.6718	143796	1100000	0.6681	146321
1110000	0.6787	140548	1110000	0.6749	143036
1120000	0.6854	137368	1120000	0.6817	139818
1130000	0.6920	134255	1130000	0.6883	136668
1140000	0.6985	131207	1140000	0.6948	133584
1150000	0.7048	128223	1150000	0.7012	130564
1160000	0.7110	125302	1160000	0.7075	127607
1170000	0.7172	122443	1170000	0.7136	124712
1180000	0.7232	119645	1180000	0.7197	121879
1190000	0.7291	116906	1190000	0.7256	119105
1200000	0.7348	114225	1200000	0.7314	116390
1210000	0.7405	111601	1210000	0.7371	113732
1220000	0.7460	109034	1220000	0.7427	111131
1230000	0.7515	106522	1230000	0.7482	108585
1240000	0.7568	104063	1240000	0.7536	106094
1250000	0.7621	101658	1250000	0.7588	103656
1260000	0.7672	99304	1260000	0.7640	101270
1270000	0.7723	97001	1270000	0.7691	98936
1280000	0.7772	94748	1280000	0.7741	96651
1290000	0.7820	92544	1290000	0.7789	94416
1300000	0.7868	90388	1300000	0.7837	92229

Exhibit I - Excess Pure Premiums

LOSSES VALUED AT 90 MONTHS

EXPECTED LOSSES = 1000000

LOSS AMOUNT	CUMULATIVE PROBABILITY	EXCESS PURE PREMIUM
900000	0.5010	230957
910000	0.5103	226014
920000	0.5195	221163
930000	0.5287	216405
940000	0.5377	211736
950000	0.5465	207157
960000	0.5553	202667
970000	0.5640	198263
980000	0.5725	193945
990000	0.5809	189712
1000000	0.5892	185562
1010000	0.5973	181494
1020000	0.6053	177508
1030000	0.6132	173600
1040000	0.6210	169771
1050000	0.6286	166020
1060000	0.6362	162344
1070000	0.6436	158742
1080000	0.6508	155214
1090000	0.6580	151758
1100000	0.6650	148373
1110000	0.6719	145057
1120000	0.6787	141810
1130000	0.6853	138630
1140000	0.6919	135516
1150000	0.6983	132467
1160000	0.7046	129481
1170000	0.7108	126558
1180000	0.7168	123696
1190000	0.7228	120894
1200000	0.7286	118151
1210000	0.7344	115466
1220000	0.7400	112837
1230000	0.7455	110265
1240000	0.7509	107747
1250000	0.7562	105283
1260000	0.7614	102871
1270000	0.7665	100511
1280000	0.7715	98201
1290000	0.7765	95941
1300000	0.7813	93729

Notes

1. National Council on Compensation Insurance, Retrospective Rating Plan D.

2. Heckman, P. E. and Meyers, G.G. "The Calculation of Aggregate Loss Distributions from Claim Severity and Claim Count Distributions," PCAS LXX, 1983, p. 22.

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