Pricing Aggregates on Deductible Policies

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Abstract

The same methods used to price retrospectively rated Workers Compensation policies can also be used to price large deductible policies that include aggregate loss limitations. In particular, a table of insurance charges ("Table M") or a modified Table M can be used to determine the incremental cost of adding an aggregate loss limit to a large deductible policy. In this study note I will start with some background, then describe the similarities of the problems, show two examples, and conclude with some general comments on using these methods to price either deductible or retro policies. I would like to thank Vadim Mezhebovsky, Eric Brosius, and especially Paul Ivanovskis for their generous help in editing this study note.

Background

Retrospectively Rated Policies

Retrospectively rated policies ("retros") have been sold since the 1930's[1], and in that time actuaries have addressed most of the pricing issues surrounding them. For example, the expected cost of imposing maximum and minimum limits on the premium ultimately owed to the insurer is often determined by referring to NCCI's Table M, or by using a similar table built by modeling the loss ratio distributions of the underlying business.

In addition to having minimum and maximum limits on the final premium, the insured who buys a retro often wants to limit the effect of *individual* large losses on the final premium. Actuaries have also developed methods for pricing this provision.

[1] The first retrospective rating plan for Workmen's Compensation was approved by Massachusetts in 1936, as described by Sydney Pinney in "Retrospective Rating Plan for Workmen's Compensation Risks", *PCAS* XXIV

Large Deductibles

Insurers started selling liability insurance policies with very large deductibles ($100,000 and up) in the 80s, and Workers' Compensation large deductible policies in 1990. Deductible policies are usually written with an aggregate limit on the amount of deductible losses the insured will have to pay. For example, a large deductible policy might state that the insured will reimburse the insurer for the first $250,000 of any individual loss but will pay no more than $500,000 in total deductible payments during the entire policy term. In this example if three losses of $300,000 were incurred during the policy term, the insured would pay $250,000 on the first two losses and nothing on the third (since the first two losses would exhaust the aggregate limit).

From the point of view of the customer, a deductible with an aggregate limit looks the same as a retro with a loss limit (with respect to ultimate losses retained). In the example above, the insured who buys a large deductible policy with an individual loss limit of $250,000 and an aggregate of $500,000 is in essentially the same position as an insured who purchases a retro with a maximum that translates to $500,000 of loss, and a per loss limit of $250,000 (ignoring the fact that there might be some differences in the treatment of expenses). The language is a little different – what we call the per claim (or per occurrence) deductible on a large deductible policy corresponds to the loss limitation on a retro; what we call an aggregate limit on a deductible corresponds to the maximum on a retro – but the general structures are the same.

Dividends

Loss-sensitive dividend plans, issued by mutual insurance companies, are also quite similar to retro and deductible plans from the customer's perspective. In a typical dividend plan the insured losses (either in total or subject to per-claim limitations) are evaluated annually for a few years. At each evaluation, if the losses are less than some predetermined amount, the customer will receive a dividend from the insurer. The predetermined amount is some fraction of the expected undeveloped loss cost at each age. There is no provision in a dividend plan for the customer to pay additional money to the insurer if losses exceed expectations, so dividend plans are typically issued in cases where the insurer believes the standard premium is more than the required premium, and the premium at issuance is equivalent to the maximum premium in a retro plan. This paper will focus on deductible policies, but the same methods are also used in pricing dividend plans.

Beyond these similarities there are various timing, tax, and accounting differences between retrospective, dividend, and deductible polices, but these are beyond the scope of this study note.[2] This study note will only deal with calculating loss costs, since grossing loss costs up for expenses and other costs is adequately covered on other parts of the syllabus.[3] (Discounting ultimate loss costs for lag in payment under this type of policy is not adequately covered elsewhere, but is nonetheless beyond the scope of this study note.)

Pricing Large Deductible Aggregate Provisions

In pricing the loss portion of a deductible policy, the actuary has the same choices as pricing a retro. The actuary can either price for the excess losses and the aggregate deductible losses simultaneously (similar to the California Table L) or can charge separately for losses in excess of the deductible and for the deductible losses in excess of the aggregate limit. The second approach is similar to the NCCI retro plan approach, which includes two separate charges, the insurance charge and the excess loss factor.

The actuary can determine these charges through the same methods used in pricing retrospective policies: she can gather a large body of policy data which is expected to be similar to that for the policies being priced, as described in Gillam and Snader[4] or Skurnick[5], and build an empirical table; she can apply reasonable modifications to some existing table, as described by Robbin[6]; or she can use information about the expected distribution of losses to model the charges, as described by Heckman and Meyers[7] and others.

In the examples below I will show two fairly straightforward methods for calculating the aggregate charge: using a modified version of Table M based on a loss ratio distribution that reflects the deductible limitation, and alternatively, using NCCI's ICRLL procedure and an unmodified Table M.

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[2] The most important difference is in the accounting of the monies that flow in addition to the initial premium. In a retro plan, future cash flows are typically premium, in a deductible plan, losses, and in a dividend plan, expenses.

[3] Teng, M.T.S., "Pricing Workers' Compensation Large Deductible and Excess Insurance", Casualty Actuarial Society *Forum*, Winter 1994, and various papers on Retrospective insurance.

[4] Gillam, W.R.; and Snader, R.H., "Fundamentals of Individual Risk Rating", National Council on Compensation Insurance (Study Note), 1992, Part II.

[5] Skurnick, D., "The California Table L", *PCAS* LXI, 1974.

[6] Robbin, I., "Overlap Revisited—The 'Insurance Charge Reflecting Loss Limitation' Procedure", *Pricing*, Casualty Actuarial Society *Discussion Paper Program*, 1990, Volume 2.

[7] Heckman, P.E.; and Meyers, G.G., "The Calculation of Aggregate Loss Distributions from Claim Severity and Claim Count Distributions", *PCAS* LXX, 1983.

Pricing the Aggregate Using a Modified Table M

The shape of the distribution of limited (or primary) losses is different from the shape of the distribution of the same losses when not subject to a limit – nevertheless, it is just another loss distribution. In particular, all the same relationships used in constructing Table M charges apply to calculating limited loss insurance charges, as described by Lee[8] or Gillam and Snader[9]. I will refer to an empirically determined table of charges for the aggregate of deductible losses as a "limited Table M", or "Table M_D", where D is the deductible amount. Table M_D is more like Table M than like Table L, because it only includes the insurance charge for the aggregate limit, and not the charge for the losses in excess of the deductible (or for limiting the retro losses). In fact, since statutory worker's compensation insurance has unlimited benefits, Table M_∞ is the same as the traditional Table M. When working with a limited Table M, it is important to remember to use limited losses consistently. The expected losses used in calculating the entry ratio must be the expected deductible (or limited) losses, and not the expected ground-up losses on the policy.

Because the size of the deductible has an impact on the shape of the aggregate loss distribution, a separate table M_D must be calculated for each deductible offered[10]. In that way the limited Table M is like Table L since it must be indexed by three variables: the expected (limited) losses for the policy, the deductible, and the entry ratio. The ICRLL procedure[11] can be used to map the three indices of M_D into the two used by the (unlimited) Table M, and can be thought of as a mapping of Table M_D onto Table M. Both the entry ratio and the size category are modified to account for the deductible.

* * *

An example of using Tables M_D to price the insurance charge of a deductible Worker's Compensation policy with an aggregate:

Expected total losses = $700,000
Deductible = $150,000
Expected Primary Losses = $500,000
Entry Ratio = 2.0 (which means the aggregate limit is 2.0 x $500,000 = $1,000,000)

[8] Lee, Y.S., "The Mathematics of Excess Loss Coverage and Retrospective Rating—A Graphical Approach", Section 4, *PCAS* LXXV, 1998.
[9] Op cit
[10] Or, at least for a sample of the most common deductibles broad enough that other values can be interpolated.
[11] Robbin, op cit. For the application of the ICRLL procedure to NCCI's Table M, see also National Council on Compensation Insurance, Retrospective Rating Plan Manual for Workers Compensation and Employers Liability Insurance (as of July 1, 2001) p A4, item 12.

Table M_D[12] for policies around $500K in size:

Insurance Charge Factor	Deductible		
Entry Ratio	100K	250K	500K
1.0	.240	.250	.260
1.5	.100	.110	.120
2.0	.030	.040	.050
2.5	.018	.022	.030

Interpolating[13] between the factor at 100K and at 250K for an entry ratio of 2.0 gives an insurance charge factor of .033, for an insurance charge of 0.033 x $500,000 = $16,500.

The total expected loss cost for this policy would be $216,500. ($16,500 plus the difference between $700,000 and $500,000.)

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Pricing the Aggregate Using a Standard Table M

The standard Table M can also be used to price the aggregate if the ICRLL procedure is used to reflect the deductible (note that this example also uses an excess loss factor to determine the cost of the deductible itself):

Standard Premium = $1M
Expected Unlimited Loss Ratio = .650
State Hazard Group Relativity = 0.9
Deductible = $250,000
Excess Loss Factor[14] = .16
Aggregate Limit on deductible = $750,000

Ground-up expected losses = $1M x 65% = $650,000.
Excess losses = 16% x $1,000,000 = $160,000

L = Limited expected loss = $650,000 – 160,000 = $490,000
Entry Ratio = 750,000/490,000 = 1.53

The Loss Group adjustment factor (ICRLL adjustment) F = [1+ (0.8 x .16/.65)]/[1 – (.16/.65)] = 1.588
The adjusted expected loss, after ICRLL and state/hazard group are taken into account, is $650,000 x 1.588 x 0.9 = 929,000
which falls into expected loss group 29
Looking this up in the excerpt of Table M below gives us a Table M charge of 0.1583, which indicates a dollar charge of 0.1583 x $490,000 or $77,567.

[12] A real Table M_D would have many more entry ratios than this simplified example.
[13] Because the differences are small, any reasonable interpolation will do. I have used a linear interpolation for simplicity.
[14] For a loss limit of $250,000, the deductible amount.

So the total expected loss cost for this policy is $160,000 + $77,567 = $237,567.

Table of Expected Loss Ranges

Expected Loss Group	Range Rounded Values
31	630,000 – 720,000
30	720,001 – 830,000
29	830,001 – 990,000
28	990,001 – 1,180,000
27	1,180,000 – 1,415,000
26	1,415,000 – 1,744,000

Table of Insurance Charges

	Expected Loss Group					
Entry Ratio	31	30	29	28	27	26
.75	.4150	.4069	.3989	.3911	.3833	.3755
.81	.3864	.3777	.3690	.3605	.3521	.3436
1.07	.2867	.2764	.2661	.2557	.2453	.2349
1.15	.2628	.2522	.2417	.2310	.2203	.2096
1.53	.1797	.1690	**.1583**	.1476	.1369	.1261

* * *

Additional Observations

To get an intuitive feel for how the distribution of deductible losses should behave, it is helpful to consider the extreme cases. A deductible policy with an infinite deductible but an aggregate limit on the deductible behaves like a retro with a max, but no per-loss limitation and a minimum equal to basic times tax. Alternatively, a retrospectively rated policy with a per-loss loss limitation but an infinite maximum behaves exactly like a deductible policy with no aggregate limit.

Using different methods to calculate the excess charges and aggregate charges can sometimes lead to disjointed results. For instance, a company might have some estimate of excess losses which is not based directly on the primary losses. In this case, the actuary should compare the sum of the predicted excess and aggregate losses, and insure that it compares reasonably with the predicted total losses on the policy. If not, an investigation of the assumptions used in estimating the excess and aggregate losses is in order.

Mismatches in assumptions can creep into calculations in all sorts of places. For instance, as Paul Ivanovskis points out, the rating bureau "pure premium" can include a number of non-loss items, such as provisions for loss based assessments and LAE. If unadjusted rating bureau ELPPFs are multiplied by a pure loss estimate, excess losses can be underestimated, sometimes substantially so. The actuary should be careful to monitor pricing assumptions for consistency and reasonability.

Also whenever an actuary is pricing a loss sensitive plan (e.g., a deductible or retrospective policy) with an aggregate limit/maximum, the actuary should be aware of the leverage that the primary loss pick has on the insurance charge. It is tempting to think that this loss pick isn't very important, because the insured is responsible for those losses. This may be true if the entry ratio is very high and the deductible relatively low, as most of the insured losses will be in the excess portion, not the aggregate portion[15]. However, if the primary entry ratio is relatively low, or the deductible is very high, much of the expected insured losses will come from the aggregate. The loss pick might be inadequate on a large account because the underwriter has been optimistic, or on a small account because the state has demanded inadequate filed rates. An excessive loss pick will also lead to an inappropriate insurance charge. Exhibit 1 below shows the impact on the insurance charge of an inadequate or excessive loss.[16]

In this example, the straight Table M charges were used, that is, this example represents a retrospective policy with no loss limitation. However, the same effect would occur on any other insurance charge priced this way (using Table M_D, ICRLL, etc.) Notice that the dollar error in insurance charges is greatest for large policies at low entry ratios, but the percent error in insurance charge is largest for large policies at high entry ratios. The percent error in the total expected losses for a deductible policy would also depend on the expected deductible losses. In any case, it is easy to see that adequate (primary) loss estimates are important to the profitability of a book of loss-sensitive policies.

[15] Of course, if the excess portion is priced as a fraction of the primary loss pick, then the primary loss pick is important in pricing this component, too.
[16] Using an inappropriate aggregate loss distribution can also produce significant pricing problems.

Exhibit 1: Sensitivity of Table M charges to the Accuracy of the Loss Pick or Rate Adequacy

If rates/loss picks are correct:
Table of $Charge

True Expected Losses	Loss Pick	Entry Ratio			
		1	1.2	1.7	2
3,000,000	3,000,000	690,000	488,400	216,600	140,700
1,000,000	1,000,000	280,000	217,000	123,400	93,000
500,000	500,000	165,000	135,200	87,700	70,550
100,000	100,000	50,000	45,140	35,960	31,910

If Rates are 10% inadequate, charges may be 30% inadequate:
Table of $Charge*

True Expected Losses	Loss Pick	Entry Ratio			
		1	1.2	1.7	2
3,300,000	3,000,000	888,030	648,450	302,940	199,980
1,100,000	1,000,000	347,270	273,790	159,720	120,890
550,000	500,000	194,425	159,775	103,345	82,665
110,000	100,000	56,716	51,315	41,041	36,454

Percent Error:

Loss Pick	Entry Ratio			
	1	1.2	1.7	2
3,000,000	(0.22)	(0.25)	(0.29)	(0.30)
1,000,000	(0.19)	(0.21)	(0.23)	(0.23)
500,000	(0.15)	(0.15)	(0.15)	(0.15)
100,000	(0.12)	(0.12)	(0.12)	(0.12)

Rates from loss picks are 12% to 30% inadequate, with the most serious Underpricing for large policies.

If Rates or loss picks are 10% excessive, charges may be 25% excessive:
Table of $Charge*

True Expected Losses	Loss Pick	Entry Ratio			
		1	1.2	1.7	2
2,727,273	3,000,000	556,091	391,909	178,091	119,727
909,091	1,000,000	233,273	180,455	104,091	79,545
454,545	500,000	140,227	114,727	74,864	60,682
90,909	100,000	44,100	39,718	31,545	27,982

Percent Error:

Loss Pick	Entry Ratio			
	1	1.2	1.7	2
3,000,000	0.24	0.25	0.22	0.18
1,000,000	0.20	0.20	0.19	0.17
500,000	0.18	0.18	0.17	0.16
100,000	0.13	0.14	0.14	0.14

Rates from loss picks are 14% to 25% excessive, With the most serious Overpricing for large policies.

* $Charge based on true "expected loss"