AUTOMOBILE BODILY INJURY LIABILITY RATE-MAKING ON A PROSPECTIVE BASIS

BY

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I. PURPOSE

Anyone who has worked in the field of Automobile Insurance Rate Making in the last few years is well aware of the necessity of having rates reflect loss costs actually incurred during the period of time that they are in effect. Although this is a perfectly obvious statement, underwriting results of recent years, especially in the Automobile Bodily Injury Liability field, eloquently demonstrate that this goal is rather elusive.

The purpose of this paper is not to supplant current rate making techniques but to supplement them.

Specifically, the purpose of this paper is to present a method for forecasting one year in advance the Incurred Pure Premium for the total writings of a given Company. By knowing this value it is then possible to evaluate the adequacy of rates for a given company so that it may meet its underwriting gain objectives.

Although the method presented here has been developed for the other automobile insurance lines, namely, Property Damage Liability; Collision and Comprehensive coverages; only the results for automobile bodily injury liability are presented since it is the author's purpose to stress method rather than actual results. Furthermore, it is believed that this method must be developed for each carrier separately. The actual results presented here should be construed as being applicable to the data considered, which was of one carrier.

II. METHOD

For the purposes here, Calendar Year (or Accident Year) Incurred Losses are defined as equal to the sum of the losses paid during the calendar year and the increase or decrease in Calendar Year Reserve during the year.

In order to forecast the value of the Incurred Pure Premium, as defined above, our problem resolves itself into determining the following:

A. An accurate method for forecasting paid calendar year pure premiums; and

B. An accurate method for forecasting beginning and ending calendar year reserves.

The paid calendar year pure premium, is of course, equal to the product of the average paid claim costs times the paid claim frequency.

Various attempts were made to forecast the pure premium rather than the average claim costs and the claim frequency but it was found that much better results were obtained by attempting to forecast these

two component parts separately. Indeed we are led intuitively to the conclusion that each should be studied separately since each is affected by different influences.

III. FORECASTING AVERAGE PAID CLAIM COST

The object here was to find a criterion for forecasting the above value one year in advance. The most obvious starting point was to try a time series but this produced wholly inadequate and inconsistent results. This led to a search for a better criterion. It was felt that the Consumer Price Index and the Wholesale Price Index, as published by the Bureau of Labor Statistics in Washington, D. C., were worthy of consideration. The values of the Consumer Price Index are based on the base year of 1953 (= 100) and in the case of the Wholesale Price Index, the average value of the years 1947, 1948 and 1949 was taken as equal to 100. In each of the indices the value for a given calendar year was equal to the arithmetic average of the values for each calendar month during the year.

Straight line and multiple correlation methods were used to correlate these economic indices and the average claim cost one year hence.

Values for average claim cost and these indices were found for each calendar year from 1936 through 1954.

On the first attempt it was found that the correlation coefficient between the W.P.I. (Wholesale Price Index) and the average paid claim cost one year hence was 0.986. It was found that the complete W.P.I. produced better results than the use of the index which excludes food and other farm products. The correlation coefficient between the C.P.I. and the average paid claim cost one year hence was 0.964. The multiple correlation coefficient between the W.P.I. and the C.P.I. was found to be 0.991. All results were indeed significant.

Although the degree of correlation was significant, further studies were made due to a rather large difference in some calendar years between the actual and calculated values. It was thought that the method could be improved by eliminating certain years. The years discarded were 1952, 1949, 1947 and 1946. The resultant multiple correlation coefficient was 0.992. The average error between actual and computed values was 3.0%. The maximum positive difference was 6.1% and the maximum negative difference was 6.7%.

Although excellent results were produced, it was observed that the method was tending to underestimate the actual values for recent years. The cause of this was a large increase (at a rate larger than the increase in volume of business) in the number of field claim adjusters in 1951. This demonstrates that any mathematical approach must be tempered by a knowledge of the carrier under study. No mathematical approach will automatically adjust itself for management and operational changes in methods and procedures. On the other hand, the need for this additional knowledge does not disqualify the merits of a sound mathematical and statistical approach in order to quantify the elements affecting losses.

What had been done was discarded and only the results for the years 1952, 1953, 1954 and 1955 were considered.

The following formula was found to produce excellent results:

$$Z_X^E = Z_{X-1}^A \left(\frac{26.649 Y_{X-1} - 1895}{26.649 Y_{X-2} - 1895} \right)$$

where: Z_X^E = estimated or forecasted value of the average paid claim cost for the year X.

Z_{X-1}^A = actual value of the average paid claim cost for the year X-1.

Y_{X-1} = Average Consumers Price Index, as previously defined, for the year X-1.

Y_{X-2} = Average Consumers Price Index, as previously defined, for the year X-2.

The above formula produced the following results:

Calendar Year (X)	*Actual Average Paid Claim Cost*	Z_X^E	*% Error of Estimate*
1952	$691	$690	(−) .14%
1953	751	758	(+) .93
1954	765	764	(−) .13
1955	783	770	(−) 1.66

Again it should be stressed that the W.P.I. and the C.P.I. produced good results with the data studied. Perhaps they would be satisfactory for other data or perhaps a different combination of these indices or even other indices would be more satisfactory for other carriers.

IV. FORECASTING PAID CLAIM FREQUENCY

The same method of study was used here as for the Average paid claim cost. That is, certain factors were made to lag the paid claim frequency by one year. The frequencies studied, were for the calendar years 1949 through 1955. The relationship between W.P.I.; C.P.I.; number of passenger car registrations country-wide; the percent of the total autos insured by the carrier etc.; and the paid claim frequency one year hence was studied, but to no avail. The problem lies in the fact that although paid claim frequency has increased each year from 1949 through 1955 that the total increase in these seven (7) years was only 13.6% or less than 2% per year. None of these criteria were sensitive enough to forecast so small a change. As a result, a straight line was established for the data using the years 1952, 1953, 1954 and 1955 by setting the 1952 value on the straight line equal to the actual value with the following results:

Calendar Year	*Actual Paid Claim Frequency*	*Computed Paid Claim Frequency*	*% Error*
1952	0.01132	0.01132	0%
1953	0.01151	0.01149	(−)0.2
1954	0.01171	0.01166	(−)0.5
1955	0.01183	0.01183	0

The above computed value equals 0.01132 minus 0.00017 times the calendar year under forecast minus 1952.

V. FORECASTING THE CALENDAR YEAR PURE PREMIUM

The forecasted value of the Calendar Year Paid Pure Premium is equal to the forecasted value of the Average Claim Cost (from III.) times the Paid Claim frequency (from IV.).

The following results were obtained:

Calendar Year	*Actual Pure Premium*	*Forecasted Pure Premium*	*% Error*
1952	$7.82212	$7.81080	(−) .14%
1953	8.64401	8.70942	(+) .76
1954	8.95815	8.90824	(−) .56
1955	9.26289	9.10910	(−)1.66

VI. RESULTS OF APPLYING THIS METHOD TO 1956

This forecasting method was developed in the first half of 1956 and at that time predictions for the entire calendar year of 1956 were made. The reader may be interested in comparing these predictions with the actual values that developed.

Item	*Actual Value*	*Predicted Value*	*% Error*
Average Paid Claim Cost	$785	$791	(+) .76%
Paid Claim Frequency	0.01215	0.01200	(−)1.23%
Paid Calendar Year Pure Premiums	$9.538	$9.492	(−) .48%

This method therefore would have predicted at the beginning of 1956 the paid pure premium for the calendar year of 1956 within ½ of 1%.

VII. THE CHANGE IN CALENDAR YEAR RESERVES

Now that we have determined a method for forecasting the paid pure premium the next step is to determine a method for forecasting the increase or decrease in calendar year reserves so that the Incurred pure premium can be forecasted.

It was found that the following method produced substantially better results than by using conventional methods for determining reserves such as case-base estimates, loss development factors, etc. The reserve method determined here was based on the premise that calendar year reserves are equal to the sum of the reserves for each accident year. The same carrier's data was used for the accident years 1942 through 1955.

The following data were available:

A. The number of claims on reserve at the end of each calendar year exclusive of incurred but not reported reserves.
B. The matured values of the claims in (A.) above plus incurred but not reported claims.
C. The number of claims paid during each calendar year.
D. The amount paid in claims during each calendar year.

Eleven full calendar years of development on 1942 accident year claims were available. It was assumed for the purpose of this study that at least 5 years of development was needed. Therefore, only the data for the accident years 1942 through 1951 were considered.

It was further assumed that we had fully matured experience on 1942 through 1946 accident year claims as of December 31, 1955. The development for the accident years 1942 through 1951 were supplemented by observing the rates of claim development for the accident years 1942 through 1956. On the basis of this "matured" experience for each accident year 1942 through 1951, the number of outstanding claims at the end of the first year, second year, third year, etc., was found along with the matured values of each of these claims.

From this data the average reserve needed was found for each accident year at the end of the current calendar year, the next succeeding calendar year, the second succeeding calendar year, the third succeeding calendar year, etc. These needed reserves at each point of development were divided by the values of the average paid claim cost one year hence as forecasted by methods already presented. The average paid claim cost one year hence was therefore used as the first measure of the average reserve need. This is reasonable for it was found that about 70% of the accident year reserve is paid out in the ensuing calendar year and about 90% within the ensuing two calendar years.

The results were examined and it was found that the following factors produced satisfactory results:

Accident Year	*Factor*
1st preceding	3.2965
2nd preceding	3.0943
3rd preceding	2.7363
4th & later	2.5616

For example, the reserve need for the accident year 1955 as of December 31, 1956 is equal to 3.2965 times the forecasted average paid claim cost for 1957 times the number of outstanding claims as of December 31, 1956 which were incurred in 1955.

It was found that although the reserve need for the current accident year varies directly with the cost of claims in the next calendar year that there is an inverse relationship with the reported claim frequency for the current calendar year.

For the current accident year it was found that the following factor multiplied by the ratio of the average paid claim cost for the next calendar year to the reported claim frequency for current calendar year gave good results:

$$36.1453(1.052)^{X-1951}$$

where "X" = calendar year under study.

The following table shows the excess or deficiency in the reserve computed by the foregoing method as compared with the true reserve need which developed:

Calendar Year	*Percent Difference*	*Calendar Year*	*Percent Difference*
1945	3.9%	1950	1.8%
1946	(—)12.1	1951	(—) .2
1947	(—) 5.5	1952	1.8
1948	1.4	1953	(—) .1
1949	(—) .5	1954	.2

The above reserve method, therefore, measures the reserve need against the cost of paying claims in the next calendar year, the year in which about 70% of the reserve will be paid out in claims. It also recognizes the fact that reserve need varies with the age of the claim at the date of evaluation. It furthermore takes cognizance of the observed fact that the short term effect of a higher reported claim frequency is to lower the reserve requirement.

The above explains the determination of year-end reserves. The following discusses the change in calendar year reserve, for if we add this change to the forecasted paid pure premium we shall obtain the Incurred Pure Premium.

The calendar year (or accident year) incurred pure premium for the next calendar year is equal to the forecasted paid pure premium for the next calendar year, plus the calendar year reserve at the end of the next calendar year minus the calendar year reserve at the end of the current calendar year. We have so far determined a method for finding the paid pure premium for the next calendar year and the reserve at the end of the current year. Our next problem is to find the reserve at the end of the next calendar year in terms of the reserves that we know at the beginning of the year. As in the case of the beginning reserve we shall treat the reserve for the current accident year separately from all other accident years.

If: R_X = the reserve per policy for the accident year "X" as of the end of the year "X" then:

$$R_X = 1.052 \times \frac{A_X}{A_{X-1}} \times \frac{N_X}{N_{X-1}} \times R_{X-1}$$

where: R_{X-1} = the reserve per policy for the accident year (X-1) as of the end of the year (X-1).

$\frac{A_X}{A_{X-1}}$ = ratio of Average paid claim cost next year to the Average paid claim cost this year.

$\frac{N_X}{N_{X-1}}$ = ratio of estimated policies in force next year to the number in force this year.

The change in reserve next year due to the accident year represented by year "X" is then:

$$R_X - R_{X-1}$$

The next item to consider is the reserve at the end of next year (X) for all prior accident years.

As of the beginning of the year, the reserve for all prior accident years except the first is given by:

$$\frac{A_X}{N_{X-1}}\left[C_{X-2} \cdot 3.2965 + C_{X-3} \cdot 3.0943 + C_{X-4} \cdot 2.7383 + \sum_{Y=5}^{Y=10} C_{X-Y} \times 2.5616\right.$$

where: "X" = year under forecast.

C_{X-Y} = number of claims outstanding at the end of the year (X—1) which were incurred in the year (X—Y).

A_X = Average paid claim cost in the year "X".

N_{X-1} = Estimated average policies in force for the year "X—1".

The reserve for all prior accident years, except the current year, as of the end of year "X" is given by:

$$\frac{A_X \cdot A_X}{A_{X-1} \cdot N_X}\left[R_1 \cdot C_{X-1} \cdot 3.2965 + R_2 \cdot C_{X-2} \cdot 3.0943 + R_3 \cdot C_{X-3} \cdot 2.7363 + R_4 \cdot 2.5616 \sum_{Y=4}^{Y=10} C_{X-Y}\right]$$

where: $\frac{A_X \cdot A_X}{A_{X-1}}$ = estimate of the average paid claim cost for the year (X+1).

and R_n = the percent of claims outstanding as of the beginning of the year, which were incurred in the n^{th} preceding calendar year, which still remain unpaid at the end of the year "X".

An examination of the data studied developed the following values of R

n	R_n
1	20%
2	35%
3	40%
4	60%

The change in reserve due to all prior accident years is of course equal to the difference between the ending and beginning values.

The total reserve change would be equal to the reserve change for the next accident year plus the reserve change for all prior accident years.

VIII. MAKING THE FORECAST OF NEXT YEAR'S LOSSES

Three alternatives are available.

First, the losses next year could be estimated by merely considering the actual paid pure premium this year and the forecasted paid premium for next year without regard to the change in calendar year reserves which has been outlined in Section VII. above.

Second, the change in reserve could be approximated by merely considering change in reserve for the accident year coincident with the calendar year under computation. In other words, the Incurred Pure Premium would be taken as equal to the paid pure premium plus the change in the current accident year's reserve.

Third, the losses next year can be estimated by considering paid pure premiums and the change in reserve for all accident years as outlined in Section VII. hereof.

SUMMARY

A method for estimating the change in Calendar Year (or Accident Year) pure premiums has been presented. This statistic can then be used to examine the adequacy of current rates or proposed rates in terms of the losses they will be expected to sustain during the period of time that they are in force.