ABSTRACT OF THE DISCUSSION OF PAPERS READ AT THE PREVIOUS MEETING

CREDIBILITY AND AUTOMOBILE RATE MAKING—ROY A. WHEELER

VOL. XVI, PAGE 268

WRITTEN DISCUSSION

MR. ALBERT H. MOWBRAY:

The casualty actuary in his use of statistical data finds himself in a somewhat different position from most other workers. They may have certain data of the past, for example a series showing the current rate of interest monthly over a period of years. They may wish to project the series into the future and want to know from the review of past data, approximately how accurate their forecast will be. They may have correlating data to work from, or as with the life insurance actuary something approximating a natural law to use as a graduation formula. He must forecast costs and recognize as fine distinctions as possible with the closest accuracy obtainable. For them the problem is, "How accurate is the result I can get from the data in hand"? For him it is often, "How much data must I have to be right within a given margin"? Perhaps it is because this heavy responsibility is not shared by others that the literature of statistics has not discussed the problem more fully. It seems to be among the most difficult in the field of mathematical statistics and probability.

Even to one whose point of observation is within sight of the Golden Gate, it must be obvious that much of the controversy regarding the rates for automobile public liability insurance in Massachusetts has centered around the variation by locality. Mr. Wheeler indicates that elsewhere the pressure is for maximum recognition of local experience data—at least when it is favorable. Under the circumstances his again bringing up this fundamental problem is timely.

If I may be pardoned a personal note, this paper wakened some unusual thoughts in my mind. Mr. Wheeler, in referring to my paper in Vol. I of the *Proceedings*, has consistently prefixed to my name an academic title which I did not then have or expect ever to have. Is it evidence that I am now regarded as having only an academic interest in casualty actuarial problems? In my private practice I am frequently still confronted with the same old problems. It is a common observation that what was radical

innovation to one generation is the bulwark of conservatism in the next. Can it be that in so short a time the test proposed at the time as a check on reliance upon what I regarded as actively inadequate data, is now the defense of reliance upon what others regard as still inadequate data? If so it would seem that our efforts as a professional body to provide a sounder basis of rates have not been wholly wasted.

Since the measure of credibility used in present automobile rate making procedure is derived from a formula developed by me and discussed in a paper in our *Proceedings* (Vol. I, p. 24), Mr. Wheeler begins by outlining the theory underlying that formula. He then properly points out its limitations, all of which were I think clear to me and other members of the Society at that time (See my "A New Criterion of Adequacy of Exposure"—*Proceedings*, Vol. IV, pp. 263 ff., and the discussion—*Proceedings* Vol. V, pp. 118 ff.), but which have since been largely lost sight of. It is natural to find that when a formula, tentatively put forward with a statement of qualifications and restrictions, has received a certain degree of acceptance its use is with increasing confidence and with increasing disregard of the limitations.

It is well, then, that Mr. Wheeler has again called attention to these limitations and conditions of use. As he points out, Mr. Barber in his May 1929 paper also called attention to one condition not carefully observed.

The first two limitations pointed out by Mr. Wheeler on p. 272 might be met by adopting the suggestion of Mr. Fisher in the discussion of my second paper (*Proceedings*, Vol. V. pp. 121 ff.) that a suitable set of frequency curves be substituted for the probability integral. Mr. Wheeler has noted this. The experience probably does tend more to follow a skew curve than the normal one on which the probability integral is based so that such a set of curves would appear better suited. In the problem in hand it is the adverse fluctuation we particularly wish to guard against and as the curves would undoubtedly be skewed to the right we could thus get a safer measure of what we desire. Whether the data exist for construction of such curves I do not know. It would appear worth investigation.

Mr. Wheeler's most serious objection to the present standard formula is its failure to recognize that variation in claim severity is also a factor in the problem of determining a dependable

statistical base for rate making. Following the provisions of the Massachusetts Workmen's Compensation law I visualized the criterion when first suggesting it as applied to data for determining partial pure premiums for separate types of benefit, i.e. assuming separate accident frequencies for each type. Mr. Wheeler suggests that something along this line may be done in automobile liability rate making. The assumption was somewhat strained for the problem first attacked by me. It seems, though perhaps it is more apparent than real, that it is more strained when dealing with the problem in relation to automobile liability case costs. There is not even that statutory excuse for division in that case.

Certainly the other alternative suggested by Mr. Wheeler of separating the pure premium into its two factors of claim frequency and claim cost is the more logical, though the other may be more practical. As he points out there is the precedent of separate determination of partial pure premium in rate making for workmen's compensation insurance.

But back of the whole problem is the fact, recognized by most company actuaries and executives, but not by the public or supervising officials, that our series are Lexian and not either Bernoullian or Poisson. With changing forces giving unstable probabilities, rates should be based on trends not on the exact indications of a fixed period whatever the volume of data.

It is unfortunate that rate making has almost always been carried on in an atmosphere of competition either between classes of carriers or between carrier interests as a class and political interests as a class under pressure of economic interests among the constituents. This has precluded the calm and dispassionate investigation of the statistical technique necessary to a sound solution of the problem.

Whether this Society independently, or in conjunction with one of our great research institutions, can provide for such an investigation under conditions that would command public confidence one cannot say. If it could be done it seems to me it would be well worth the cost in time and money. It might take more time but would probably cost no more money than has been expended by the fire insurance interests in rate litigation. The investigation, if undertaken, should be broad enough to include the statistical aspects of rate making in all branches of insurance.

MR. HARMON T. BARBER:

Mr. Wheeler's paper on credibility and automobile rate making is worthy of a much more extensive study than the writer has been able to apply. However, a brief review of the paper has developed several pertinent thoughts which may be of interest to others in studying the problem of what constitutes a dependable experience and how should these criteria, after they have once been determined, be used in the development of automobile rates.

The treatment accorded to credibility up to the present time in the development of automobile rates is undoubtedly open to question and criticism. Mr. Wheeler in his paper points out a number of the theoretical weaknesses and gives supporting evidence based on the experience accumulated under the Massachusetts automobile compulsory liability insurance law. The deductions drawn by Mr. Wheeler from his study of these data are undoubtedly correct but some of the apparent instability of automobile experience as revealed by several of the exhibits may be attributed to two factors, the extent of whose influence is problematical. It seems wise to make note of these points or, otherwise, the extent of variation in automobile experience data might assume exaggerated proportions. In the first place, the experience used as a basis for the exhibits is composed of the first two years under the Massachusetts compulsory insurance law, a period which covers the transition from voluntary insurance to compulsory insurance. It seems obvious that claim settlements made during this time should be characterized by a considerable degree of uncertainty both as to frequency and amount. It may be that this lack of homogeneity is responsible for a considerable share of the variation in experience apparent from a review of the exhibits.

Again, in several of the exhibits, the experience of individual towns grouped by volume of annual exposure has been related to a state average. The geographical limits of towns offer a convenient unit for experience purposes, although perhaps not always a proper one. For example, the towns of Chelsea and Revere have a limited annual exposure and are probably grouped in the exhibits with rural or suburban towns of a much larger area. Experience has demonstrated that the automobile personal injury hazard in Chelsea and Revere is as high as in any other section of the state, while there are probably other towns grouped with these two in the exhibits which have a much less pronounced

hazard. It might have been possible, therefore, to have eliminated some of the variation in claim cost and frequency if the towns had been segregated into groups corresponding with present day rate territories before the studies were made.

The impression is gathered from portions of Mr. Wheeler's paper that variations in average claim cost between towns in many cases are largely fortuitous. While this is true to a degree, the point should not be overlooked that the level of claim settlements for a particular territory is frequently governed to a large extent by local court judgments. Many claims which are settled entirely outside of court by agreement between the injured party and the claim adjuster are influenced by such occurrences as a particularly liberal judgment rendered on a liability case which has gone to suit. Therefore, it is to be expected that part of the variation in claim cost between territories may be due to a real inherent difference in the scale of settlements. The average claim cost is probably a poor statistical measure of this inherent difference in claim settlements between territories owing to the fact that a relatively infrequent claim of substantial size may have a marked effect on the mean claim cost. If it were possible to readily obtain the median cost from a distribution of claims for a particular territory this might serve as a better index of relative cost.

This thought suggests a modification of Mr. Wheeler's second proposal for the development of automobile rates. He proposes that claims costing more than $1,000, could be distributed over a wide territorial basis as a loading on the pure premium developed by claims costing less than $1,000. If the limiting amount could be varied by territory, using some such index as the median claim cost as the basis for this adjustment, certain objections to the unmodified proposal would be eliminated. For example, it is to be expected that the rates for a high-class residential suburb where settlements are substantial, though infrequent, as developed under the modified procedure, would probably be more appropriate than the rates developed under the original proposal without the modification. The other suggestion offered by Mr. Wheeler for a change in the method of developing automobile rates calls for a variation in pure premium within a particular area in proportion to the variation in claim frequency as tempered by the use of credibility. It is to be expected that the lack of volume of

experience in states other than Massachusetts would be a decided handicap in the development of automobile rates by this method. It probably would be difficult to set up broad territories with a sufficient volume of experience to comply with the recommended requirement for unit credibility as to claim cost without sweeping into such territories certain towns with a local claim cost at variance with the average claim cost of the territory. If the proposed method should produce rates higher than those based upon actual losses as used at the present time, it might be difficult to satisfy the public as to the reasonableness of the method. At the present time it is of considerable assistance in the selling of rate increases to state that the rates have been based upon actual losses occurring within the territory.

Both of the methods suggested by Mr. Wheeler merit further study and test. It would be interesting to compare rates developed by each of these methods with the rates produced by the present rate making procedure for some particular state. Under present conditions the ultimate judgment as to the worth of many innovations in casualty rate making must be based on the results produced by a practical application of the method rather than by a study of the underlying theory.

AUTHOR'S REVIEW OF DISCUSSION

MR. ROY A. WHEELER:

Mr. Mowbray expresses general agreement with the conclusions of the paper and suggests that the investigation might properly be extended to cover trends as well as the exact indications over a fixed period of time. It would be rather difficult to inject the idea of trend into the limited volume of exposure without sacrificing some of the value to be derived from such limited volume of exposure available. It might be possible, however, to consider the problem of trend in total or in subdivisions of the total where sufficient exposure is available.

A further handicap in the matter of trend is the reliability of the most recent policy year as compared with the older policy years. This difficulty might be avoided by a standardization in reporting accidents and claims and, secondly, by more detailed and complete reports having to do with review of reserve estimates whereby it can be more definitely determined that where symptoms existing

in previous years gave rise to underestimated reserves, similar symptoms in the most recent year might be eliminated without bridging the gap upon an assumption which is difficult to sustain.

As a specific application of the theory contained in the original paper, we have prepared the attached exhibit, showing the results by towns of a rating on the basis of the proposed credibility formula and in comparison with the actual rates adopted for Massachusetts for the calendar year 1930.

The criticism of Mr. Barber that the variation in automobile experience in Massachusetts is not typical may be valid although further experience for the year 1929 appears to conform to the conclusions suggested in the original paper based upon the experience of the years 1927 and 1928.

In regard to Mr. Barber's criticism that the experience of individual towns has been related to a state average, he has apparently misinterpreted both the tables and diagrams. In order to overcome the very objection which he mentions, of grouping towns of small exposure but high hazard with towns of small exposure and low hazard, variation for the analyses was measured as the percentage departure of the individual town from its own two year average. These variations of individual towns were further grouped by size of exposure as shown in the summary tables contained in the original paper. It is true that in certain towns there was a noticeable difference in hazard from the average of their group. This does not offset the general conclusion that variation in claim frequency, claim cost and pure premium decreases inversely with exposure, but in varying degree. The effect of one town in which there was a noticeable difference in hazard in any group would not make any appreciable difference in the result since the method of measuring such variation was either the median or the standard deviation.

I agree with Mr. Barber's statement that the average claim cost is a poor statistical measure but the median which he proposes is of less value since it apparently lies between $50 and $75 for all towns and territories. The upper quartile value might be a better measure of the difference in claim cost between towns since it varies less than the mean but more than the median.

Along the same line, Mr. Barber suggests the possibility of using the median claim value in determining the size of claim to be eliminated from the rate of the individual city or town and spread over a broad territorial basis. It has been shown that the median

could be too small for this purpose but the suggestion that the value of excess claims should vary by territories is a good one. A preliminary test indicates that the upper decile value—that is the value of the claim dividing the upper 10 per cent. from the lower 90 per cent. of the claims arrayed according to size—lies between $500 and $600 and might be the splitting point in determining excess losses.

I do not agree with Mr. Barber's thought that the lack of volume of experience in states other than Massachusetts would be a decided handicap in the development of automobile rates by the methods proposed. He states that if the proposed method should produce rates higher than those produced on actual losses it might be difficult to satisfy the public as to the reasonableness of the method. If the experience in Massachusetts is any criterion, the rates obtained under the proposed plan approach more closely to the experience in the local community than rates obtained under the present plan based upon a broad territorial average. This is borne out by the Massachusetts rates as shown on the attached table in which rates under the proposed plan are lower than the present rates in a majority of cases. This is due to the fact that bad experience in a few individual localities is sufficient to raise rates in a large number of cities and towns with a smaller exposure.

COMPARISON OF STATUTORY PUBLIC LIABILITY RATES IN MASSA-
CHUSETTS FOR PLEASURE CARS IN 1931 UNDER THE PRESENT
RATING PLAN AND UNDER THE PROPOSED PLAN

The present rate making procedure establishes an average pure premium based upon the average experience for a group of cities or towns in which conditions are substantially similar. This system has operated to the disadvantage of many towns whose experience has been better than the average and the obvious advantage of other towns whose experience may have been decidedly worse than the average. The experience of each town should have more weight in deciding the final rate for that town than is allowed under the present system.

Basis of Computation

Previous investigations have shown that the most important factor affecting changes in rates from year to year is a change in average claim cost. One or two serious accidents costing $5,000 or $10,000 in a town of moderate size are sufficient to cause a large

increase in the average claim cost from year to year which in turn increases the pure premium or the average loss per car. It has been shown that claim frequency, or the number of claims per 100 cars for any individual city or town, shows much less variation from year to year than claim cost. The proposed method of establishing pure premiums for each city or town takes both claim frequency and claim cost into consideration.

The towns and cities included in the first seven rating territories have been divided into four groups for purposes of computing rates. The first group consists of all cities and towns sufficiently large so that their rates may be based entirely upon their own experience without adjustment. The cities and towns included in this group qualify under two credibility standards: a very high standard based upon claim cost and a much lower standard based upon claim frequency. Therefore, all cities and towns in which experience for the three years 1927 to 1929 inclusive is sufficient to give 100 per cent. credibility for claim cost have been rated entirely upon their own experience. The requirement for 100 per cent. credibility is an exposure sufficiently large to insure a variation of not more than 5 per cent. from the three year average claim frequency in 99 cases out of 100. This is the same standard that has been used in determining territories by the Massachusetts Automobile Rating and Accident Prevention Bureau.

The second group consists of cities and towns in 1930 territories IV, V, and VI, in which experience is such that they receive a credibility of less than 100 per cent. on the standard outlined above but for which credibility for claim frequency is 100 per cent. The requirement for 100 per cent. credibility for claim frequency is a variation of not more than 10 per cent. from the three year average in 95 cases out of 100.

The pure premium for this group was determined from the following formula:

$$P = \frac{Ae \times F}{100}$$

in which P equals pure premium to be obtained; Ae is the average claim cost for the group; and F is the claim frequency for the individual town expressed as the number of claims per 100 cars. The pure premium thus obtained is a direct function of accident frequency and as such is a direct reflection of difference in hazard,

but is not influenced by accidental variations in the claim cost
within any single town.

The third group consists of cities and towns in 1930 rating terri-
tory VII, in which credibility is less than 100 per cent. for claim
cost but which show 100 per cent. credibility for claim frequency.
The pure premiums for this group were obtained in the same man-
ner as for the second group. The average claim cost for the group
was applied to the claim frequency as outlined above. The only
difference is that the average claim cost used was 8 per cent.
higher than for the second group.

The fourth group consists of all cities and towns in 1930 rating
territories VI, and VII, in which credibility for both claim cost
and claim frequency was less than 100 per cent. The pure pre-
mium for this group was calculated as follows: The average claim
cost for the group was applied to the accident frequency for each
individual city or town. The pure premium thus obtained was
given a weight equal to the credibility of the city or town on a claim
frequency basis. The complement of this credibility was applied to
the average claim frequency for the group times the average claim
cost. This may be summarized in the following formula:

$$P = \frac{(Ae \times F) \times Z + (Ae \times Fa)\,(1\text{-}Z)}{100}$$

in which P, Ae, F, have the same connotations as above and in
which Fa represents the average claim frequency of the group;
Z equals credibility on a claim frequency basis, and 1-Z is the com-
plementary credibility.

The pure premiums thus obtained are based entirely upon the
average claim cost of the group but the claim frequency of the
individual city or town is given a weight equal to its credibility
while the average claim frequency of the group is given a comple-
mentary weight. The pure premium, therefore, represents a
weighted average between the claim frequency experience of the
group and the experience of the individual city or town.

Adjustment

After calculating pure premiums by the method outlined above,
the application of pure premiums thus derived to the exposure for
each city and town did not produce the total losses actually re-
ported. Therefore, it was necessary to adjust the pure premiums

by a percentage in order to give an adjusted pure premium which, when applied to the reported exposure, would exactly reproduce losses as reported.

Differentials for W, X, and Y

Differentials for W, X, and Y, are based upon group averages. Boston is the only city in which experience for each classification is sufficiently large to give W, X and Y pure premiums based entirely upon actual experience. The other cities and towns in Group I were given the average W, X and Y differential for the group, that is the experience for each classification was totalled and related to the average and the percentage thus obtained was applied to the adjusted pure premium. Differentials for each of the other groups were obtained in the same manner.

A final adjustment was made by applying the calculated pure premiums for each class to the exposure and comparing losses thus calculated with actual losses as reported.

The pure premiums for W, X, and Y cars for all towns in each group were adjusted by this indicated percentage difference in order to obtain a set of pure premiums which would reproduce a~tual losses.

GROUP I—Cities and Towns with Sufficient Experience to give 100 per cent. Credibility on Claim Cost and Claim Frequency.

	Pure Premium			Rate		
	W	X	Y	W	X	Y
TERRITORY I—CHELSEA						
Present Plan..............	$41.28	$43.22	$51.60	$84.00	$87.00	$80.00
Proposed Plan............	50.43	54.02	62.76	78.19	83.75	97.30
TERRITORY II—REVERE						
Present Plan..............	36.77	38.70	46.44	57.00	60.00	72.00
Proposed Plan............	44.57	47.74	55.47	69.10	74.02	86.00
TERRITORY III—BOSTON						
Present Plan..............	34.14	36.97	42.48	53.00	57.00	66.00
Proposed Plan............	34.14	36.97	42.48	52.93	57.32	65.86
TERRITORY IV						
Present Plan..............	27.74	28.38	36.12	43.00	44.00	56.00
Proposed Plan—Cambridge...	28.02	30.02	34.88	43.44	46.54	54.08
Somerville...	25.76	27.59	32.06	39.94	42.78	49.71
TERRITORY V						
Present Plan..............	20.64	23.87	28.38	32.00	37.00	44.00
Proposed Plan—Brookline....	22.74	24.36	28.30	35.26	37.75	43.88
Malden......	26.71	28.61	33.24	41.41	44.36	51.53
Newton.....	18.54	19.86	23.08	28.78	30.79	35.78
Quincy......	20.84	22.34	25.95	32.31	34.64	40.23
TERRITORY VI—Lynn..........	25.08	26.87	31.22	38.88	41.66	48.40

GROUP II—Cities and Towns with Sufficient Experience to give 100 per cent. Credibility on Claim Frequency but less than 100 per cent. on Claim Cost.

	Pure Premium			Rate		
	W	X	Y	W	X	Y
TERRITORY IV						
Present Plan................	$27.74	$28.38	$36.12	$43.00	$44.00	$56.00
Proposed Plan—Everett......	32.94	37.96	46.55	51.07	56.85	72.17
Winthrop....	29.92	34.48	42.28	46.39	53.46	65.55
TERRITORY V						
Present Plan................	20.64	23.87	28.38	32.00	37.00	44.00
Proposed Plan—Arlington....	19.59	22.58	27.68	30.37	35.01	42.91
Belmont.....	16.36	18.86	23.12	25.36	29.24	35.84
Dedham.....	18.72	21.58	26.46	29.02	33.46	41.02
Medford.....	22.39	25.80	31.64	34.71	40.01	49.05
Milton......	18.08	20.84	25.56	28.03	32.31	39.63
Watertown..	19.37	22.38	27.38	30.03	34.70	42.45
Winchester..	18.49	21.31	26.13	28.67	33.04	40.51
TERRITORY VI—Melrose.....	18.72	21.58	26.46	29.02	33.43	41.02
Peabody.....	23.25	26.80	32.86	36.05	41.55	50.95
Salem.......	19.16	22.08	27.07	29.71	34.23	41.97
Saugus......	23.46	27.04	33.15	36.37	41.92	51.40
Waltham....	18.30	21.09	25.86	28.37	32.70	40.09
Wakefield...	16.14	18.61	22.82	25.02	28.85	35.38
Woburn.....	19.59	22.58	27.68	30.37	35.01	42.91

GROUP III—Cities and Towns with Sufficient Experience to give 100 per cent. Credibility on Claim Frequency but less than 100 per cent. Credibility on Claim Cost.

	Pure Premium			Rate		
	W	X	Y	W	X	Y
TERRITORY VII						
Present Plan................	$16.13	$19.35	$23.22	$25.00	$30.00	$36.00
Proposed Plan—Beverly.....	15.05	17.40	20.19	23.33	26.98	31.30
Braintree....	16.44	19.00	22.04	25.49	29.46	34.17
Danvers.....	17.00	19.54	22.66	26.36	30.29	35.13
Framingham.	16.44	19.00	22.04	25.49	29.46	34.17
Haverhill....	14.59	16.85	19.55	22.62	26.12	30.16
Lawrence....	18.29	21.15	24.52	28.36	32.79	38.02
Lexington...	17.60	20.34	23.59	27.29	31.54	36.56
Lowell.......	20.83	24.09	27.93	32.29	37.35	43.30
Methuen....	15.76	18.20	21.11	24.43	28.22	32.73
Natick......	14.12	16.33	18.93	21.89	25.32	29.35
Needham ...	15.05	17.40	20.19	23.33	26.98	31.30
Norwood....	20.61	23.82	27.64	31.95	36.92	42.85
Swampscott .	18.29	21.15	24.52	28.36	32.79	38.02
Wellesley....	13.66	15.80	18.32	21.18	24.50	28.40
Weymouth...	16.20	18.74	21.73	25.12	29.05	33.69

GROUP IV—Cities and Towns with Insufficient Experience to give 100 per cent. Credibility on either Claim Frequency or Claim Cost.

	Pure Premium			Rate		
	W	X	Y	W	X	Y
TERRITORY VI						
Present Plan..............	$20.64	$23.87	$28.38	$32.00	$37.00	$44.00
Proposed Plan—Lynnfield....	16.18	20.60	25.14	25.09	31.32	38.98
Stoneham...	16.87	21.48	26.22	26.16	33.30	40.65
TERRITORY VII						
Present Plan..............	16.13	19.35	23.22	25.00	30.00	36.00
Proposed Plan—Abington....	12.20	15.53	18.96	18.92	24.08	29.40
Andover.....	10.56	13.44	16.41	16.37	20.84	25.44
Avon........	15.42	19.63	23.96	23.91	30.43	37.15
Billerica.....	16.66	21.22	25.90	25.83	32.90	40.16
Burlington...	15.04	19.15	23.38	23.32	29.69	36.25
Canton......	18.25	23.23	28.36	28.30	36.02	43.97
Chelmsford..	13.52	17.21	21.01	20.97	26.68	32.57
Cohasset....	11.85	15.09	18.42	18.37	23.40	28.56
Dover.......	12.92	16.45	20.08	20.03	25.50	31.18
Dracut......	17.33	22.06	26.93	26.87	34.20	41.75
Hingham....	12.37	15.75	19.23	19.18	24.42	29.81
Holbrook....	13.51	17.20	20.99	20.95	26.67	32.54
Hull........	15.29	19.47	23.77	23.71	30.19	36.85
Lincoln......	16.57	19.82	24.20	24.14	30.73	37.52
Marblehead..	13.28	16.91	20.64	20.59	26.22	32.00
Nahant......	19.90	25.33	30.92	30.85	39.27	47.94
No. Andover.	12.51	15.93	19.44	19.40	24.70	30.14
No. Reading.	15.25	19.42	23.70	23.64	30.11	36.74
Randolph....	20.07	25.55	31.19	31.12	39.61	48.36
Reading.....	14.19	18.07	22.06	22.00	28.02	34.20
Rockland....	11.03	14.04	17.14	17.10	21.77	26.57
Stoughton...	15.48	19.70	24.05	24.00	30.54	37.29
Tewksbury..	16.33	20.80	25.39	25.32	32.25	39.36
Tyngsboro...	13.20	16.80	20.51	20.47	26.05	31.80
Wayland....	15.28	19.71	24.06	23.69	30.56	37.30
Weston......	12.66	16.12	19.67	19.63	24.99	30.50
Westwood...	13.59	17.30	21.11	21.07	26.82	32.73
Wilmington..	22.34	28.44	34.72	34.64	44.16	53.83

NOTES ON EXPOSURE AND PREMIUM BASES—PAUL DORWEILER

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WRITTEN DISCUSSION

MR. A. N. MATTHEWS:

The members of the Society and especially Associates who are about to prepare for the Fellowship Examinations should be very grateful to Mr. Dorweiler for the preparation of this paper which deals with a subject that is fundamental to the principal lines of casualty insurance. This paper not only gives the basis of premium for each line, but also gives the reason why the basis of

premium which is used in each case is preferable to other possible bases. For a student who is just beginning his work in casualty insurance this paper will give a very complete introduction to the more complicated details which are to follow.

In connection with this study of premium bases it might be well to mention the various lines of property damage and collision which are usually written in conjunction with the corresponding lines of public liability. Public liability insurance covers bodily injury to the public, whereas the corresponding property damage lines cover damage to the property of the public arising out of conditions for which the assured is responsible. Collision insurance covers the owner against damage to his own property which results from accidents for which he is responsible or for which the person who is responsible is financially unable to indemnify the owner. In the case of property damage and collision the basis of premium is the same as that used in connection with the corresponding public liability. In most cases the exposure to the property damage hazard will vary in direct proportion to the public liability hazard. As a matter of fact, in the case of most accidents which are covered under some forms of liability coverage, especially automobiles and teams, it is a matter of pure chance whether the accident results in bodily injury, property damage, or a combination of the two. The only lines of public liability for which corresponding collision coverage is necessary are those which cover accidents arising out of the operation of a vehicle, namely automobiles, aircraft and elevators. Insurance which covers the property of the owner in case of accidents resulting in damage to aircraft is usually referred to as "crash" insurance.

In the case of most lines of insurance there is one basis of premium which is so far superior to all others that it has been definitely established and premium rates are always calculated on that basis. However, there are a few exceptions to this rule, the most important of which are the public liability coverage on motor buses and passenger carrying airplanes. For example, a company operating motor buses may have its premium based on car-years, livery earnings, or the payroll of the bus operators. A further modification of the car-year basis is the so-called "automatic coverage" basis under which the assured keeps a record of the number of days for which each bus is operated. Thus, under this coverage the amount of premium depends upon the exact

number of bus-days. In the case of motor buses the premium usually covers both injury to passengers and also injury to members of the public other than passengers. When the passenger hazard is excluded from the coverage a discount in the premium is allowed.

On the other hand, in the case of passenger carrying airplanes the probability of injury to persons other than passengers is very small as compared with the probability of injury to passengers and, therefore, the passenger hazard is considered entirely separate from the public liability hazard other than passengers and in some cases a different premium basis is used for the two coverages on a single risk. The public liability premium excluding the passenger hazard is usually determined on the basis of airplane-years, whereas there are a number of different premium bases for the passenger hazard which are usually determined to conform with the records which are kept by the assured. The most common premium bases used are passenger miles and gross income.

In the case of the fidelity and surety lines the unit of exposure is usually expressed in terms of hundreds (or thousands) of dollars of penalty per year. In the case of automobile embezzlement coverage, however, the car is the unit of exposure. Other bases of exposure used in these lines are number of employees, units of penalty running into many thousands of dollars, number of branches covered and the price paid for work to be done. Thus, it is seen that the wide diversification of the forms of coverage afforded by means of fidelity bonds makes it impossible to establish a single premium basis which will fit all forms. For this reason, each form of coverage must be carefully analyzed and the most desirable means of measuring the hazard decided upon.

As was previously pointed out, Mr. Dorweiler has covered the premium bases for all the major lines of casualty insurance. In the above discussion an attempt has been made to extend the territory covered into the less important casualty lines for which the basis of premium is somewhat different than that for those lines which were considered by Mr. Dorweiler.

MR. WILLIAM F. ROEBER:

Students of the Society should be grateful to Mr. Dorweiler for his very comprehensive paper pertaining to exposure and premium bases. A review of the *Proceedings* discloses the heretofore utter lack of material on this fundamental subject.

The paper may be divided into two parts, first, a theoretical treatise developing in a systematic manner the concept of the "evaluation standard" and second, an outline of the possible premium bases together with the advantages and disadvantages of each, for the various lines of insurance. The sound logic evident throughout the paper could emanate only from a mathematically trained mind.

In discussing the merits of the several premium bases, Mr. Dorweiler weighs the theoretical against the practical and strange as it may seem in an actuary, it is my opinion that he leans to the practical as being of primary importance, the theoretical aspects coming into play only as an aid in deciding between two bases equally practical.

The practical exposure media, for third party liability cases (i.e. where the assured himself is not the injurable object), is subject to division into prospective and retrospective measures of exposure. The following outline, based on this approach, may be of interest to the student.

I. Prospective Measures of Exposure (fixed).
    1. Area and frontage
    2. Man-year
    3. Seat-year
    4. Unit-year
    5. Elevator-year
    6. Team-year
    7. Car-year
    8. Plane-year
    9. Bed-year

II. Retrospective Measures of Exposure (variable).
    1. Payrolls
    2. Number of admissions
    3. Quantity of product
    4. Units of product
    5. Total sales
    6. Receipts and admission charges
    7. Rentals

MR. ROY A. WHEELER:

In the manufacturing and mercantile lines of business it is customary to take a periodic inventory. From the standpoint of the Casualty Actuarial Society it seems equally desirable to make a periodic inventory of the theory upon which certain casualty practices are founded. The exposure and premium bases should be examined at rather frequent intervals in order to evaluate their limitations and to take advantage of any improvements that are possible.

Mr. Dorweiler is to be complimented upon a concise summary of the various bases of measuring exposure and collecting premiums. Dependence upon any basis is likely to increase with use, regardless of its theoretical soundness. Therefore, Mr. Dorweiler's discussion is a timely one.

The first qualification of a desirable medium for a premium basis is given as one having a magnitude varying directly with the hazard when a hazard is measured by losses. This is a qualification with which there should be no disagreement. However, the second qualification may possibly be interpreted as an argument for the present basis rather than as a theoretical justification for all bases. This qualification, as stated, is that it is desirable to have a medium, the magnitude of which may be readily ascertained and which is already used by assured for other than insurance purposes. If this qualification had been established at the inception of certain lines of casualty insurance it would have been impossible to develop a scientific procedure in the measurement of hazard and in the collection of premiums. If this qualification is accepted it may preclude the use of measures of exposure that may be found more reliable in the future.

In discussing the payroll basis of measuring exposure and collecting premiums, more emphasis might well be given to the weak points of this base. While these limitations are noted in passing the actual effect is, perhaps, more serious than Mr. Dorweiler has been willing to admit. He recognizes that payroll "does not respond fully to the variation in losses to the extent that the losses are legally restricted by the maximum weekly payments and by the maximum amount paid on any case." In many skilled mechanical trades and in the building trades fluctuations in wage rates may produce rates that are grossly inadequate or redundant

due to the fact that the general wage level in these industries is
high enough so that losses will not be affected by such a change.
For instance, if the average wage in the building trades in New York
is $50.00 per week a cut in this wage to $40.00 per week due to a
reduction in hourly wage rates would not affect losses to any
noticeable extent, since two-thirds of the reduced wage would
still be in excess of the maximum weekly compensation payment
of $25.00.

Mr. Dorweiler states that the effect of the maximum cost either
weekly or in total in reducing the extent to which payrolls reflect
losses, is less at the present time than during the early days of
workmen's compensation due to increase in benefits. I am in-
clined to believe that the situation is reversed and that the effect
of maximum weekly benefits and amounts paid is greater now than
formerly. This may be illustrated by the provisions in the New
York law. The original act provided that for temporary total
benefits the weekly payment should be two-thirds of the wage
with a minimum of $5.00 and a maximum of $15.00. The present
law has increased the minimum to $8.00 and the maximum to
$25.00. Wages in a great many lines are more than double what
they were in 1914, the date of the original act. The average factory
wage in New York in 1914 was $12.48, compared with $29.99 in
1929. (New York Industrial Commission.) The minimum weekly
payment has increased only 60 per cent. and the maximum about
65 per cent. The maximum amount of payment has been increased
from $3500 to $5000, or an increase of less than 50 per cent.

It seems probable that compensation benefits have not increased
as rapidly as wage rates and payrolls during this period. If this
is true, Mr. Dorweiler's assumption will not hold and payrolls
are less reliable as a measure of hazard (losses) than formerly.

A payroll base for medical charges is even more unstable than
for indemnity. It is true that medical losses vary with time ex-
posure but it does not necessarily follow that they vary with wages.
The weakness in assuming that medical losses vary with wages is
in the assumption that the medical fee scale and wage scale re-
spond to the same general price level. This is directly contrary to
medical experience which has shown a constantly increasing trend
without reference to fluctuations in price levels or wages. In
short, the present payroll basis has numerous practical and theo-
retical limitations and the time may be approaching for further

careful study in order to measure the effect of such limitations. A more careful analysis of the limitations of our basis of exposure in public liability lines may also be found desirable.

The discussions of "Notes on Exposure and Premium Bases" have contributed to the subject under consideration by presenting supplementary information, by directing attention to specific features, and by scrutinizing the observations of the author. Mr. Matthews has extended the scope of the paper through his supplementary notes on premium bases for additional casualty insurance lines. Mr. Roeber has given consideration to the prospective and retrospective features in exposure media and classified them accordingly. Mr. Wheeler has presented critical comments particularly on the qualifications listed and the treatment of the payroll exposure medium.

In outlining the two qualifications for an exposure medium, they were given as *desirable* to denote that they were not absolute but rather something to be approximated. The word *preferably* was used in stating the second qualification to convey the idea that, other things being equal, the medium already in use for other purposes had the advantage. It was pointed out that the final rating was to depend on a combination of the two qualifications without attempting to establish the relative weight of each. Generally, the first qualification is of primary importance. However, in instances where two or more media vary reasonably with the losses, the second consideration may properly govern the selection even though a slightly less accurate measure of the hazard is thus chosen. Also in lines of insurance where the cost is low, the relative importance of the second increases and may even surpass the first. The classification system also enters into the relative importance of the two qualifications. In classifications composed of risks widely divergent in hazard, there is obviously little to be gained by superimposing a highly refined method for measuring exposure.

Mr. Wheeler is of the opinion that not sufficient emphasis has been given to the weak points of the payroll exposure basis and

that these are perhaps more serious than the author is willing to admit. It would seem that in Mr. Wheeler's quotation from the original paper the case is stated rather completely, even though there is no elaboration. The concrete example which Mr. Wheeler gives to show the defects of the payroll basis is fully covered in the more general statement in the original paper—see *Proceedings*, Vol. XVI, page 326, 3 *Man-Year*, second sentence.

When making the statement—*Proceedings*, Vol. XVI, page 324, last two sentences—that the effect of limits on losses had been reduced by law amendments which raised the limits, the author had in mind the period centering about 1918 when national basic pure premiums were first used in rate making. However, as there is nothing in the printed statement which restricts the meaning of "earlier Compensation laws" definitely to this period, Mr. Wheeler's objection is quite in order.

It is common observation that over extended periods medical fees and wages have advanced together, though not consistently in any constant ratio. In the states where lower wages prevail the medical fees are generally lower than in states where higher wages prevail. Similarly in rural districts with lower wage levels, the medical fees are lower than in urban centers where wages are higher. These relations imply a certain responsiveness between medical fees and wage levels even though there is not the direct causal relation that exists between indemnity cost and payroll. Medical costs which are made up of a combination of medical fees and number of accidents should have somewhat this same responsiveness to payrolls.

Final judgment on the selection of payroll as the exposure medium should depend not on how payroll exposure responds to medical and indemnity costs separately but on its responsiveness to the combination of the two. Furthermore, the judgment should depend not on how payroll responds to the given standards in an absolute sense but rather on how its merits and demerits stand relatively with those of other available media when measured by the same standard.

The author quite agrees with Mr. Wheeler as to the desirability of further study of this subject. In the original paper the author tried to define the problem involved in measuring exposure, to outline the underlying principles, and to discuss briefly their application to the more important casualty insurance lines covering

injuries to human beings. It was hoped that this general survey of the problem of measuring exposure, which is of greater relative importance in casualty insurance than other lines, might induce others to treat this problem perhaps in individual casualty lines in a somewhat exhaustive manner.