SCIENTIFIC METHODS OF COMPUTING COMPENSATION RATES.

I. M. RUBINOW.

Theoretically the problem of compensation rates does not differ from that of rates in many other forms of insurance. The formula for premiums in any classification appears as $\left(\dfrac{\text{payroll}}{\text{losses}}\right)$ plus any loading for commissions and expenses agreed upon or found necessary. There is only one difficulty about this formula—we do not know the numerator of this fraction, under which condition it is not quite an easy matter to compute its value.

The same formula is the basis of liability insurance, and time is relied upon to furnish the necessary volume of exposure, without which the results of the fraction are likely to be purely accidental and subject to violent fluctuations. That a large exposure is necessary to produce a true average, or in other words, that the fluctuations will be in inverse proportion to the size of experience is a truth which does not require any proof before a body of insurance men. It is quite evident, therefore, that it will take a long time under compensation experience before that necessary volume of exposure shall have been gathered.

It is obvious, however, that compensation rates must be quoted as soon as a compensation law goes into effect, and for some time after that while the necessary volume of experience is being accumulated. This presents the first difficulty.

It is true that the United States is not a pioneer in compensation insurance. In various countries experience has been accumulating for many years, up to as long as thirty years in Germany. The question is often asked by many persons outside of the insurance circles why the result of European experience in regard to pure cost cannot be utilized in this country. There are a good many reasons for this. The one that is mentioned first of all is perhaps the least important one. It is argued, and with a good deal of justice, that industrial conditions in Europe and in this country are not similar, that accidents happen more frequently in the United States, and,

therefore, the pure premiums would not be equal. While this is undoubtedly true in a great many industries, it is by far not the greatest difficulty. More important are the differences in the compensation scales, of which the losses are results. And finally, there is the greatest handicap which statisticians will especially appreciate.

European statistics are seldom published, or even prepared in such detail as to give the necessary data for each separate classification. We have in our manual approximately 1,500 different classifications, and their number is rapidly growing. This results from the praiseworthy effort to do justice to each line of industry, to charge it no more than its hazard requires. It is almost impossible to oppose this tendency towards fine distinctions, for if rough grouping were insisted upon, the way would be open to the competitor to select the least hazardous subdivisions of each classification, and underbid on them. It is useless to look in European statistical sources for the pure premiums on any of the subdivisions of "Concrete Work" or "Masonry" or such odd classifications as "Military Goods Mfg."

Proceeding from the formula $\text{Pure Premium} = \dfrac{\text{Losses}}{\text{Payroll exposure}}$, therefore, we seem to be thrown back upon our resources, upon the necessity of compiling our own experience which requires time before the necessary experience is accumulated. At first glance, it would seem that the greatest difficulties are already behind us.

In New Jersey, compensation is nearly three and a half years old; in Illinois, some two and a half years old; in Massachusetts, twenty-eight months, and so on.

But that only slightly relieves, and does not altogether abolish all difficulties. As against these two or three states, we have states like New York, or Iowa, where compensation is only four months old, Maryland, in which the compensation went into effect a week ago, Kentucky and Louisiana, where January 1 is the fateful date, and about a score of states in which the compensation acts are in various stages of preparation or contemplation. In all of these states compensation rates have to be quoted to-day, or to-morrow, or in the very near future. And yet no experience exists. It is not too much to say that no other country in the history of the compensation movement presented a problem of similar complexity, since none had an avalanche of compensation acts, no two alike, no two

coming in at the same time. As a result, while the situation be-
comes somewhat simplified in some states, because of the accumula-
tion of experience, it arises in all its difficulties in other states, and
relief is not yet in sight.   ·

Moreover, there remains the greatest, most fundamental difficulty
in applying this method, which even years of experience may not
eliminate. Because of the existing division of the country into
some fifty independent legislative units, the possible exposure in
one classification will be insufficient in one state to produce an
average, except in so many years, that meanwhile conditions may
entirely change, and make the accumulated experience entirely
useless. That unfortunately is true of the greatest number of classi-
fications. Of course, there are exceptions, in states as well as in
classifications. New York, industrially, is an empire of itself.
The exposure in most classifications will be so large that in com-
paratively few years a true average will have been obtained. In
other smaller states, the exposure may be sufficiently great in a few
industries, for which the state may be famous. Massachusetts does
not need the aid of other states to obtain a true broad experience in
boots and shoes. The same may be true in cotton spinning and
weaving in South Carolina, or beer brewing in St. Louis or Mil-
waukee.

But how about the vast majority of diversified industries? The
readiness to go by a small volume of experience is one of the pecu-
liar errors of early underwriting in this country. When the Massa-
chusetts Insurance Department compiled and published its famous
schedule Z, for 1913, showing the compensation experience for sep-
arate classifications, it very wisely decided that below a certain
minimum of exposure the experience was not worth presenting.
The accepted minimum was very small—only $500,000, and yet
only 134 out of the possible 1,500 were able to pass that test. But
such an exposure is hopelessly inadequate to produce even an indi-
cation of an accurate rate.

The average pure premium in Massachusetts was some 36 cents.
Let us assume that an ordinary fatal accident would cost $2,400.
One fatal accident, therefore, in a certain classification represents
a pure premium of 48 cents on half a million of exposure, 24 cents
on a million of exposure. One fatal accident, therefore, may double
the pure premium in many a class. The purely accidental fact that

of two fatal accidents in two different classifications, one happened to a married employe, and another to an unattached bachelor, may produce a wide margin between the two costs and two premiums. Only then may we begin to speak of a dependable experience when at least one accident will not seriously disturb the average pure premium. If a certain classification has a pure cost of $1, then an exposure of $10,000,000 may be sufficient, because one $2,000 or $3,000 loss will not affect the pure premium more than 2 per cent. or 3 per cent. But in less hazardous occupations, where the pure premium may be ten or twenty cents, a very much larger exposure will be necessary to produce results that are actuarially dependable. And if that is so, how long will it take some of the smaller states to accumulate such volume of experience? For instance: When will Nebraska be able to determine its pure premium on "suspenders without buckles," or Rhode Island on "butchers' supplies"? And yet rates must be quoted for either, and moreover they must be adequate and equitable.

Some two years ago I pointed out this difficulty in an article in *The Market World and Chronicle,* and suggested the necessity of grouping the numerous classifications. In fact, I had the temerity to announce that in my leisure hours, and after burning a good deal of midnight oil, I had prepared a tentative grouping of classifications. Immediately numerous requests from state departments and casualty companies arrived for copies of this grouping. The state of Wisconsin adopted it with some modifications.

The Massachusetts Insurance Department now very anxiously urges such grouping into some 150 groups according to similarity of hazard. The Bureau has recently adopted this suggestion, and a tentative grouping of classifications has been prepared by several members of its statistical committee which finds expression in the mysterious classification numbers found in the Basis Manual. The need for such grouping is well illustrated by the fact that the chief of the Federal Bureau of Labor Statistics has expressed his anxiety to publish it as an official document. Nevertheless, too much reliance must not be put on it in the beginning. Its aim is to group together classifications of similar hazard—but what do we know of exact measurements of hazard? That is the very thing that experience must in the future produce. For hazard is not to be measured by the likelihood of producing accidents, but by the actual

causation of such hazards. Theoretically, equal hazard is to be defined as the factor which produces the same number of accidental injuries, and also the same distribution of accidental injuries per equal exposure in different classifications. At present the measurement of hazard is only an opinion, euphoniously called underwriting judgment, while actuarial science as well as sound business requires that rates be based on *facts*. The grouping of classifications must, therefore, be tested by actual experience, and again a sufficient volume of exposure is necessary for such testing.

The conclusion is inevitable, therefore, that some method of combining experience of different states is absolutely necessary, if we are to arrive at scientific rates within a reasonable time. That is true even after compensation has been written for some years. And in the beginning it is doubly necessary that some method be devised other than that of actual experience under each separate act, so that some use be made of every scrap of information both American and European.

I hope that I shall not be charged with undue pride for stating that nearly two and a half years ago I outlined the elements of such a method, which was further developed by such well known actuaries as Professor A. W. Whitney and Mr. A. H. Mowbray, and though it met with a considerable opposition in the beginning, succeeded in becoming the foundation upon which all the present compensation rates are built. In an article published in *The Market World and Chronicle* (June 22, 1912), I indicated that the compensation pure premium for any classification resolved itself into three factors: first, the accident rate; second, the distribution of accidents according to gravity, or according to the nature and duration of the injury, and third, the compensation scale. Knowing these three factors, we could compute the cost of a hundred or a thousand accidents, or what amounts to the same, the average cost of an accident, and apply it to the accident frequency for each classification.

This is the bare outline of the plan as suggested at the time. The compensation scale is known—it is stated in unmistakable terms in the law. American students approaching the problem usually assumed that there were no definite data in regard to the other two factors, accident frequency and accident gravity. It appeared then to me that the problem was not an impossible one. The insistence of American casualty companies upon receiving reports of all acci-

dents to employes if assured is well known. Accidents are reported in this country to casualty companies very much better than, for instance, in England, as personal inquiries have convinced me. An evidence is the very much smaller proportion of claims to accidents in this country than in England. I hoped at the time that perhaps casualty companies might see their way to undertake such an investigation in their files. It has never been done, and, therefore, this part of the plan has a purely historical interest at present. But since it was argued at the time that such an investigation was altogether impossible, I want to point out that it is being done now on a very much smaller scale every day in the compilation of experience for merit rating, and will be done at the very much greater rate from now on.

It was argued at the time that liability accident reports were worthless even for obtaining accident frequency only, but now they are being used for accident gravity as well.

The main contribution of my plan was contained in the suggestion that European experience might be utilized for the purpose of distributing accidents into groups according to gravity. Though an extremely simple and almost obvious suggestion to any one who has made any study at all of foreign accident statistics and could not fail to be struck by the identical results in all countries, it appeared like a new scientific clue to many actuaries who were groping for some practical method of computing the cost of compensation. Professor A. W. Whitney was the first, I believe, to apply it. Mr. A. H. Mowbray tested it critically and found a good deal of evidence to corroborate what he was kind enough to designate as "Mr. Rubinow's hypothesis." I believe for some time it was even good-naturedly referred to as "Rubinow's law."

While both these students could not use the methods outlined for the purpose of computing actual rates (because the necessary factor of accidental frequency was lacking) they both, entirely independently of each other, utilized it for a somewhat more modest purpose of measuring the comparative costs of different compensation acts and bills. Justice requires me to state, therefore, that the Rubinow hypothesis became a workable instrument of actuarial science only after the application made by Professor Whitney and Mr. Mowbray.

The first official sanction was given to the method by the New York Insurance Department in the work of establishing the basis

for New York compensation rates.* No one interested in compensation matters needs be reminded of the brilliant work done so recently by Mr. W. W. Greene. The disputable question as to final differential need not be gone into here, lest this peaceful meeting break up in a riot, but the final triumph of the method used by him (of measuring the comparative values of compensation scales by applying a standard table of accident gravity) cannot now be disputed.

The material which Mr. Greene and the department was forced to use for lack of time was not the very best. The Massachusetts distribution of accidents was highly unsatisfactory, the Austrian figures used, without any correction, may have been somewhat one-sided, nevertheless it was the first large effort in the preparation of law differentials.

The problem which the New York Insurance Department had to solve was that of differentials only. But the casualty companies and the assured needed something vastly more difficult—they needed actual rates. The methods by which they were computed are recent history, and need not be described in any great detail. The formula used was:

Basic Pure Premiums $\times$ loading for underestimates $\times$ law differential $\times$ loading for expenses $= 1 \times 1.08 \times 2.00 \times 1.50 = 3.24$.

The basic pure premium was obtained from the original formula $\dfrac{\text{Losses}}{\text{payroll,}}$ but since the payments had not all been made, and there was reason to believe that the estimates on outstanding payments were somewhat insufficient, these were loaded by an arbitrary amount. The law differential and the expenses for loading were equally results of compromises.

Our judgment of the value of the formula must be entirely independent of our opinions as to accuracy of the individual factors. It clearly appeared that some such formula was necessary so long as rates had to be quoted for some states for which experience did not exist at all, or was altogether insufficient.

In this process of adaptation the question of a proper law differ-

* Since this has been written, my attention was called to the fact that in 1913 Mr. E. H. Downey and Mr. J. Black used this method for the purpose of computing differentials for Illinois, Iowa, Michigan and Minnesota, as compared with the Wisconsin Act. (See "Workmen's Compensation, Second Annual Report, July 1, 1912 to June 30, 1913," published by the Industrial Commission of Wisconsin, 1913.)

ential was of paramount importance. At this juncture Professor Whitney conceived the fruitful idea of appointing a differential committee to devise a method of computing law differentials, and actually to compute such differentials which should be acceptable to all because of their evidence of scientific impartiality, if not absolute accuracy.* How successful this proposal was can be proven by the remarkable fact that the differential committee was able to make unanimous reports of all differentials which they prepared including some fifteen states. As compared with acrimonious discussions following the New York law differential this represents a noteworthy achievement. It may be designated as the first victory of the principle upon which this society is built—the principle of unbiased scientific inquiry applied to casualty problems.

Law differentials had been used before in the preparation of compensation rates, but represented rather crude guesses or estimates. It is a comparatively easy problem to measure the comparative provisions of the law in regard to a certain group of accidents. If, for instance, the New Jersey Act grants 50 per cent. and the New York Law 66⅔ per cent. in certain cases, then they will cost one-third more in New York than in New Jersey.

The difficulty arises in trying to measure the differential for all the provisions of the law, when each particular difference must be carefully weighed. Evidently this will depend upon the distribution of accidents according to gravity or severity. The statisticians of the Wisconsin Industrial Commission, who have endeavored to compute a few law differentials, recognize this, and use the distribution of accidents in Massachusetts and in Wisconsin adding the data together, and obtaining a total of some 115,000 accidents. But while the results obtained were fairly satisfactory this method suffers from all the shortcomings of the statistics used. Massachusetts included all notices; Wisconsin, largely only accidents over seven days' duration. The systems of distribution were different in the two states, and unsatisfactory in either; especially in regard to accidents resulting in permanent disability, are these data faulty, because the condition of permanency cannot be ascertained in the short time within which both Massachusetts and Wisconsin data were compiled. Furthermore, in regard to several problems, such

* The committee consists of Mr. B. D. Flynn, Mr. Stanley L. Otis, Mr. C. E. Scattergood, and the writer.

as the number of dependents or the influence of limits, no information at all was available.

At this point the usefulness of the "Rubinow hypothesis," or "Rubinow Law" came in. Briefly, it may be stated thus:

Given a sufficiently variegated industrial activity, the distribution of accidents according to their physical results will be fairly uniform anywhere.

With the help of this hypothesis, the following method for computing law differentials was agreed upon:

Construct a standard accident table, showing such distribution by severity in all necessary details. Compute the value of compensation for this standard series under any law, and the ratio of this cost will be the law differential. As the basic premiums were thus obtained from Massachusetts experience, the Massachusetts value of the table was the basis for computing differentials.

The first step in this method was the construction of the standard table, a duty which I was fortunate enough to be entrusted with.

Popular fancy is a very mysterious thing. One never knows what may or may not please it. The 100,000 accidents of the Standard Table have quite unexpectedly for its author acquired quite a little reputation for themselves. Both the roundness and the bigness of the number seemed to impress popular imagination. In his article in the *Survey*, Mr. Benedict speaks of them as 100,000 accidents actually gathered from European experience. As a matter of fact, that is not accurate. The 100,000 is simply an extension of the percentage method. It seems preferable to use whole numbers rather than decimal fractions, carried out three places beyond the decimal point. The large number seemed necessary in order to permit their distribution in sufficient detail. The entire statistical material used in its preparation is too voluminous for presentation here. It is hoped that it will be possible to publish it in some other form. Moreover, the details are of purely statistical and of slight actuarial interest. It is sufficient to state that statistics of accidents in Germany, Austria, France, Belgium, Italy and Russia, in Massachusetts, Washington, California, and other states was utilized in this connection. The total number of accidents included in the data analyzed literally runs into millions. The following questions require an answer (in each case per 100,000):

1. The number of fatal accidents.

2. The number of cases of total permanent disability.

3. The number of dismemberments, distributed according to their exact nature.   .

4. The number of cases of permanent partial disability, other than dismemberments.

5. Their distribution according to degree of impairment of earning capacity.

6. The number of cases of total temporary disability.

7. Their distribution according to duration of disability (by weeks intervals).

8. The duration of total temporary disability in cases which result in dismemberments, or in other forms of permanent partial disability.

9. The number of fatal cases leaving total, partial or no dependents.

10. The number of widows, children, or other dependents surviving in those states where the death compensation is made dependent upon the number or kind of dependents surviving.

Briefly the standard table accepted by the committee embodies the following facts:

Fatalities 932
Total permanent disability 133
Dismemberments 2,300
Other permanent partial disability 2,442
Total temporary cases 94,193

Before any criticism of this distribution is offered, it is very important to remember that almost for the first time in American statistical literature, it has been based upon a very definite interpretation of an accident.   This definition adopted by the Statistical Committee of the Bureau, and promising to become the standard definition through the United States, excludes all accidents where the injured person loses no time except on the day of injury; and according to the Massachusetts report, some 40 per cent. of accidents reported are of such trivial character.   Naturally this increases the proportion of the serious accidents in the table.

To return to the actuarial problems.   The standard table, or the 100,000, was taken through the mill of the compensation law of each state.   Since the benefits almost universally are stated in proportion to week's wages, it was found convenient to utilize week's wages as a unit of measure rather than dollars and cents.   It is but fair to add that in this the committee utilized the precedent estab-

lished by Mr. Greene. In a few cases where the benefits are meas-
ured in money units, it was therefore necessary to reconvert these
into week's wages by an assumption of an average weekly wage.
That was true of funeral expenses and medical aid. Where long
term payments are granted it was decided to utilize commuted values
in the computation. Since a true differential between states was re-
quired, it did not seem scientific to disregard the factor of commuta-
tion, especially because in certain acts and for certain benefits the
facts of mortality had to be taken into consideration. Annuities cer-
tain were used where the provisions of the law made probable that
the total benefits would be paid to dependents even if one of them
died during the time. Term annuities were used in most cases; life
annuities where life pensions were granted, and deferred annuities
in a few cases where the benefits consisted of a preliminary larger,
and a deferred smaller annual amount. The effect of limit was
measured by obtaining statistics of wages of injured persons and
computing the cost of compensation both with and without limits.

For the computation of the cost of medical aid, no theoretical
method presented itself, but fortunately experience data as to pro-
portion between compensation and medical cost were available for
a few states, and from these fairly reasonable estimates could be
made for other states with slightly different provisions. The
methods as thus recited appear complex. The committee would
readily admit that they are not simple. While the computation of
the first state differential took nearly a week, recently two differ-
entials were computed in one day, and that, we feel, is a record that
cannot be very much improved upon. Are the rates based upon
these differentials absolutely right? That is the question that is
most likely to be asked. No one is so little inclined to make this
claim as the committee. Yet I am sure that I voice the conviction
of all its members in stating that barring possible individual errors,
the rates are, on the whole, the most scientific that ever were com-
piled in this country, and the best that could be compiled with the
material as yet available.

While I am willing to stand by this claim, I am equally con-
vinced that they are temporary only, and that possibly in two or
three years, a complete revision, or readjustment will be necessary,
and also possible, if meanwhile accurate statistical data are accumu-
lated by the casualty companies.

Let us, therefore, frankly, though briefly, enumerate the elements
of weakness in the method of rate computation:

1. The Basic Rate.—It is a trite observation that a chain is no stronger than its weakest link. As I have explained earlier in this paper, one year's experience in one state is not enough. When the Massachusetts experience, under the older law, is revised for the entire period, July 1, 1912–October 1, 1914, substantial changes will be made in most, if not all pure premiums, and further changes may become necessary if the experience of the states is combined.

2. The Law Differential.—This may have to be changed somewhat because of errors found in the Standard Table. As soon as records of a few hundred thousands of accidents are carefully studied in this country, the necessity for a hypothetical standard table will have vanished. Personally, I cherish the hope that the errors disclosed will not be very essential. Naturally, I cannot believe that the "Rubinow Law" is all wrong. Yet there are factors in it that are not altogether physical, such as the determination of degree of disability. The California schedule for instance differs materially from the schedules used in Europe, and similar differences between states may develop.

3. The construction put upon certain provisions of the laws may not have been altogether accurate. In a few cases, the committee was not altogether certain of its interpretation, especially in cases where the Act had not yet gone into effect. It is necessary to add, however, that the members of the committee carefully watch decisions of commissions and courts as to such interpretations.

4. A bigger problem, however, is the fundamental accuracy of applying the same law differential to all classifications. As already explained, the law differential depends upon the distribution of accidents as to severity. But while such distribution must be uniform, on the whole, as between one state and another, it differs materially, as between industries. The proportion of accidents resulting fatally, for instance, will be greater in a coal mine than in a clothing shop. Theoretically different standard accident tables should be compiled for each classification, or at least, for each large industrial group. But altogether outside of the enormous labor involved in such an undertaking, there are no data from which such tables could be constructed. We may feel that we have accomplished a good deal in achieving justice as between one state and another, without claiming equal justice between classifications.

5. The Question of Comparative Accidental Frequency.—That the physical and moral hazard is not equal throughout our great coun-

try any one will readily admit, but no one has prepared the necessary material for a convincing measure of the extent of such differences. Most extravagant statements, as to these differences, are often made. It is almost impossible either to prove or to disprove them. In a very few cases small allowances were made for them in establishing rates. To some extent the methods of schedule rating and experience rating recently established will tend to discount these differences. But nothing less than trustworthy accident statistics can settle this question to the satisfaction of all. If errors have been made, their cost is but the inevitable price of obtaining valuable business experience.

6. Finally, we must come back to a point mentioned earlier. The basis of a true rate is the basic pure premium, and yet for most classifications no one state can ever expect to have sufficient experience to produce a true pure premium. Compensation rates throughout the country cannot indefinitely be depended upon Massachusetts pure costs. Moreover, compensation rates in Nebraska cannot depend upon pure costs in Nebraska only, nor rates in Maryland upon Maryland costs. For each classification the experience of the entire country will have to be utilized. In so far as this experience is physical, and expressed in terms of accident frequency and severity, it will be adapted to universal use. And in so far as that experience is expressed in dollars and cents, the methods of law differentials will enable us to bring together accidental losses in all states, make proper allowances for the differences in the law, deduce a basic pure premium from them, and from that basic pure premium, derive pure premiums for each state which may differ materially from the actual costs in these states, and yet represent a truer measure of hazard.

Time does not permit me to go into the further details of this larger plan, which is premature at the present moment, anyway. But the statement cannot be made too emphatic that while the present rates may be the best that could be, their subsequent improvement depends entirely upon the development of accident statistics. The Bureau's careful and comprehensive plan, recently adopted, is well known. As actuaries and statisticians, we all look forward to its realization. Perhaps the casualty companies do not quite realize its cost. The plan may call for a study of 500,000 accidents annually, and that represents a comprehensive statistical undertaking, requires a substantial force and an efficient statistical

outfit. But the casualty business needs the results, and no other body is likely to furnish them. The hope that the industrial commissions and accident boards will furnish these data has been cherished by many. But a careful analysis of the reports as yet turned out by Massachusetts, Wisconsin, California, Washington, Ohio and other states shatters the hope, at least for some time. Each one of these reports is interesting and to some extent valuable, but an effort to bring them together produces a maze of dissimilar data, absolutely barren of any tangible actuarial results. Given the political organization of our country, a statistical union of casualty business is as yet the only hope of valuable statistics. It should be the function of our young organization to see that the qualitative results of such co-operation should be worthy of the effort and expense required in its realization.