DISCUSSION BY DAVID SKURNICK

This paper tells how regression analysis was used to relate Workers' Compensation premiums and losses to various economic variables. Messrs. Lommele and Sturgis conducted a lengthy and complex study combining statistical and actuarial techniques and finally arrived at three models that they considered acceptable.

Model I says annual countrywide Workers' Compensation written premium equals 0.6% of total adjusted wages disbursed, plus a constant of $289 million. The wage adjustments take into account rate level changes, the percentage of the work force covered, and the effect of payroll limitations. This model meets the author's statistical criteria, and it tends to confirm a reasonable relationship: an increase in wages, in rate level, or in percentage of work force covered, or a decrease in the effect of payroll limitation is associated with an increase in premiums.

Perhaps the constant term should have been omitted. Its presence implies that a certain percentage increase in adjusted wages is associated with a smaller percentage increase in premium. At first glance it appears that these rates of increase should be identical, but rising wages may have been associated with increasing self-insurance. In any event, the constant term is not too significant for current years. It is only about 6% of the 1973 premium, although it constitutes nearly 40% of the 1948 premium.

Model II says that a year's incurred loss equals 58% of the prior year's incurred loss, plus 0.2% of adjusted wages, plus $11.5 million times the unemployment in percent, minus a small constant of $18 million. This model is important because it indicates that a percentage point increase in the unemployment rate is associated with an $11.5 million increase in incurred losses, and this relationship is shown to be statistically significant.

In one respect Model II is unappealing to the intuition. It says that a percentage point increase in unemployment is associated with a fixed dollar increase in losses regardless of the magnitude of the year's losses. The incurred loss was $426 million in 1948 and $3.6 billion in 1973, so the model implies that in 1948 a percentage point increase in unemployment would have raised

losses 2.6%, but in 1973 a percentage point increase in unemployment would have raised losses only 0.3%. This reviewer believes that the variables are related in a multiplicative fashion. For example, Model II might be replaced by:

$$\text{Model II}': \quad \text{LOSS}_i = A\,(\text{PRODUCT}_i)^{B_1}\,(\text{UNEMP}_{(i-1)})^{B_2}\,(\text{LOSS}_{(i-1)})^{B_3}\,(\text{error}),$$

or its equivalent:

$$\text{Model II}'': \quad \log \text{LOSS}_i = A + B_1 \log \text{PRODUCT}_i + B_2 \log \text{UNEMP}_{(i-1)} + B_3 \log \text{LOSS}_{(i-1)} + \text{error}.$$

Linear regression can be used to estimate the parameters of Model II". Incidentally, readers should be warned that Model II in the paper measures current year's loss in thousands of dollars but measures prior year's loss in dollars.

Actuaries commonly estimate a year's earned premium as the average of the current and prior years' written premium. Model III shows that this approximation is not accurate for Workers' Compensation; in fact, the premium earned in a year depends almost entirely on the premium written that year, and only slightly on premium written the year before. As the authors state, this situation results from the general practice of collecting substantial additional audit premiums. Also, a log in entering premium onto the company books will cause several months worth of premium to be earned the month the written premium is entered.

Over the years there have been periods when Workers' Compensation loss ratios increased and periods when they decreased. Recently, sharp increases have led to unprofitable underwriting experience in most jurisdictions. A primary motive for the Lommele-Sturgis study was to explain Compensation's recent unprofitability.

It is disappointing to report that the authors failed to solve this problem. The only clue they discovered is that an increase in unemployment seems to cause a small increase in losses. The recent high loss ratios may result from social factors that cannot be quantified. However, before we conclude that regression analysis cannot be used to find an explanation for the rising loss ratio, we should try out many other reasonable models. In particular models should be tested in which the dependent variable is loss ratio at current rate and benefit levels. Such models would measure changes in profitability more directly than the ones here, which estimate premiums and losses separately.

Thanks to the authors' hard work, this paper demonstrates high technical quality. The paper is itself a model — a model of how a study ought to be conducted. The authors sought out many external sources of economic data. They graphically tested the variables for a linear relationship before adopting a linear model. Each proposed model was tested and evaluated on the basis of seven criteria. The authors measured the error in each model, so one can estimate how accurate its predictions would be. They also discuss autocorrelation and how to adjust for it — a most serious concern in the study of time series.

Regression analysis can be a useful tool for the actuary, and this paper will encourage and help other actuaries to work with linear regression. The Society owes a debt of gratitude to the authors for their efforts in this important field of research.