DISCUSSION OF PAPER PUBLISHED IN VOLUME LXXXIII

ESTIMATING THE PREMIUM ASSET ON RETROSPECTIVELY RATED POLICIES

MIRIAM PERKINS AND MICHAEL T. S. TENG

DISCUSSION BY SHOLOM FELDBLUM

1. INTRODUCTION

Perkins and Teng have provided us with a new and remarkably intuitive procedure for estimating the accrued retrospective premium asset: the PDLD (premium development to loss development) approach. This reserve is often significant—amounting to half a billion dollars or more for some of the major workers compensation carriers—and it has been difficult to accurately estimate with traditional procedures. The paper by Perkins and Teng should greatly enhance our actuarial repertoire.

Specifically, the PDLD method has several distinct advantages over other procedures:

1. It is modeled directly on the retrospective rating formula, so it is easily explained to underwriters and claims personnel who are familiar with retrospectively rated policies.
2. Its emphasis on the premium sensitivity in the retrospective rating formula parallels the risk-based capital loss-sensitive contract offset in the underwriting risk charges and the new loss-sensitive contract Part 7 of Schedule P. For regulators familiar with the risk-based capital formula and with the statutory accounting requirements, this loss reserving approach is a natural complement to the statutory procedures.

3. The procedure may prove particularly useful when changes in the retrospective rating plan parameters distort the indications of other methods.

There are few existing methods for estimating the accrued retrospective premium asset, and the indications are often highly uncertain. The PDLD approach will enable actuaries to estimate this asset more accurately.

This discussion has two parts.

1. The complexity of the reserve estimation procedures for the accrued retrospective premium asset often hides the rationale of these methods from the average reader. The first part of this discussion uses graphical representations of Fitzgibbon's method and of the PDLD method to show the rationale behind each method and to explain the advantages of the latter method.[1] We then show how to combine the better parts of the two methods to improve the PDLD procedure.
2. The second part of this discussion highlights the implications of the Perkins and Teng procedure for the calculation of the loss-sensitive contract offset to the underwriting risk charges in the risk-based capital formula and for the use of Schedule P, Part 7, to estimate premium sensitivity.[2]

2. THE PDLD PROCEDURE

This section addresses two issues:

1. How does the PDLD procedure differ intuitively from Fitzgibbon's procedure, and in what ways is it better?

[1]See Fitzgibbon [6], F. J. Hope [8], Unthoff [11], Berry [2], and Morell [10]. The term "Fitzgibbon's method" in the text includes the enhancements provided by Berry and Morell.

[2]The term "premium sensitivity" stems from the term "loss-sensitive contracts." This paper uses the term "premium responsiveness" to refer to the same phenomenon.

2. What aspects of Fitzgibbon's procedure can be added to the PDLD procedure to enhance its accuracy?

Let us begin our inquiry with a more fundamental question. Why not estimate the accrued retrospective premium asset the same way that we estimate loss reserves? That is, why not use a chain-ladder development procedure on historical triangles of either collected premium or billed premium? This would be the premium analogue to a chain-ladder development procedure using either paid losses or reported losses.

Indeed, Schedule P already does this. Part 6 of Schedule P shows historical triangles of exposure year earned premiums by line of business (for all types of contracts), and Part 7 of Schedule P shows historical triangles of policy year earned premium on loss-sensitive contracts (all lines of business combined). Why go through the complexities of Fitzgibbon's method or the PDLD method when a straightforward chain ladder development method would suffice?

The underlying rationale of Fitzgibbon's method and the PDLD method is that

a. estimates of ultimate incurred losses can be obtained sooner than estimates of retrospective premiums can be obtained, and

b. retrospective premiums depend on incurred losses.

In workers compensation, for instance, a good estimate of ultimate incurred losses is generally available soon after the expiration of the policy, since claims emerge rapidly and development on known claims is relatively stable. The first retrospective adjustment, however, occurs about six months after the expiration of the policy. The retrospective premium may not be billed and collected for an additional three months after the adjustment is done.

Using Fitzgibbon's method or the PDLD method, an initial estimate of the accrued retrospective premium asset can be produced soon after the policy expires, using the known loss information and the relationships between incurred losses and retrospective premium. Similarly, the accrued retrospective premium asset estimate can be updated each quarter, as new loss data becomes available. If a chain-ladder premium development procedure is used, however, the initial estimate cannot be produced until at least nine months after the policy expiration, and it can be updated only annually thereafter.

The reserve estimation procedures in both Fitzgibbon's method and the PDLD method are based upon the retrospective rating formula. They differ in the details, not the concept, although the details can be crucial for reserve estimation. Using graphs to clarify the methods, the two approaches will be compared and contrasted using the following steps:

- how premium is determined in the retrospective rating formula;
- how Fitzgibbon, followed by Berry, converts the premium determination procedure to a reserve estimation procedure;
- what problems arise in the reserve estimation procedure, and how Berry resorts to a second reserve estimation procedure to resolve them;
- how the PDLD procedure modifies the original Fitzgibbon procedure to solve the aforementioned problems, without having to resort to a second reserve estimation procedure; and
- how part of Fitzgibbon's procedure can be used to enhance the PDLD procedure, giving users the best of both worlds.

Retrospective Premium Determination

Fitzgibbon's method and the PDLD method both seek to replicate the premium determination procedure in the retrospective rating formula. Of course, a single reserving formula cannot perfectly replicate hundreds of slightly different rating plans. Nevertheless, the more successfully the reserving procedure can replicate the rating procedure, the more accurate will be the reserve estimates. So let us begin with the premium determination formula.

The retrospective premium is composed of two parts:

1. Part of the premium covers the incurred losses, as well as any expenses associated with these losses, such as loss adjustment expenses. However, not all losses enter the retrospective rating formula. There is a loss limit, which means that individual losses exceeding a certain amount—such as \$250,000—do not affect the retrospective premium adjustments. In addition, state premium taxes, as well as other state assessments (such as involuntary market loads) are levied on the premiums, whether they are standard premiums or retrospective premium adjustments.

   The retrospective rating plan expresses this part of the premium as

   $$\text{(loss conversion factor)} \times \text{(incurred losses)} \times \text{(tax multiplier)},$$

   where the loss conversion factor (LCF) covers primarily loss adjustment expenses.

2. The other part of the premium covers company expenses and the insurance charge. Company expenses are all expenses that are not a direct function of losses, such as underwriting expenses and acquisition expenses.

The insurance charge results from the maximum and minimum limitations on the retrospective premium. Having a maximum premium, of course, is the whole purpose of insurance. The insured needs protection against the unanticipated large losses that it cannot prudently retain. But the insurer must collect premium to cover these large losses. So the insurance charge is the difference between

a. the expected loss (to the insurer) caused by the maximum premium and

b. the expected gain (to the insurer) caused by the minimum premium.

The expected loss is the average additional amount of premium that the insurer would have collected had there been no maximum premium limitation. The expected gain is the average amount of premium that it would not have collected had there been no minimum premium limitation.

This charge must also cover any premiums lost because of the loss limits, which cap the individual loss values entering the retrospective rating plan.[3]

As before, a provision must be added for state premium taxes and other state assessments. This part of the premium may be expressed as

$$[(\text{expense provision}) + (\text{insurance charge})$$
$$+ (\text{excess loss charge})] \times (\text{tax multiplier}).$$

[3]The computation of the insurance charge is the standard Table M and Table L calculation. For the "formula" approach in the PDLD method, which can be used with Fitzgibbon's method as well, the reserving actuary may have to recompute certain Table M or Table L charges.

For simplicity, the first three components are combined into the basic premium, so the expression above can be restated as

$$(\text{basic premium}) \times (\text{tax multiplier}).$$

Thus, the formula for the retrospective premium is

$$\begin{aligned}\text{Retrospective premium} &= (\text{tax multiplier})\\ &\quad \times [(\text{basic premium}) + ((\text{loss conversion factor})\\ &\quad \times (\text{limited incurred losses}))].\end{aligned}$$

The Reserving Formula

The formula above is the rationale for Fitzgibbon's reserve formula. Premium is assumed to be a linear function of the incurred losses, or

$$\text{Retrospective premium} = C + B \times \text{Losses}.$$

The pricing formula becomes the reserving formula. For application to an entire book of business, Fitzgibbon and Berry make two modifications to this basic equation:

1. They use ratios to standard premium. That is, they write

$$\begin{aligned}&\text{Retrospective premium} \div \text{Standard Premium}\\ &\quad = K + B \times \text{Standard Loss Ratio},\end{aligned}$$

   where $K = C \div \text{Standard Premium}$.

2. They examine the retrospective adjustment. In other words, they subtract unity from both sides of the equation above, to get

$$\text{Retro Adjustment} = A + B \times \text{Standard Loss Ratio},$$

   where $A = K - 1$.

The Historical Regression

Fitzgibbon and Berry estimate the parameters *A* and *B* from a historical regression, using standard loss ratios and retrospective adjustments from mature policy years. But the attentive reader might observe that the two parameters in Fitzgibbon's formula depend on the parameters in the retrospective rating formula. So why do they use a regression analysis on past experience? Why don't they just walk over to the pricing actuary in the next office and ask what parameters are used in the retrospective rating plan?

Actuarial reserves are typically estimated on an aggregate basis, for all states, all insureds, all policy years. The parameters, however, vary from year to year, from state to state, and from plan to plan. For instance:

- A small insured may purchase a plan with a low maximum premium and therefore a large insurance charge, whereas a large insured may prefer a plan with a high maximum premium and a low insurance charge. Also, larger insureds may be offered plans with lower expense provisions, since their underwriting and acquisition expenses as a percentage of standard premium are lower than for smaller insureds.
- Premium taxes differ from state to state. In addition, some retrospective rating plans include involuntary market expense loads as a part of the tax multiplier, and the involuntary market loads vary widely among jurisdictions.
- The basic premium may vary from year to year. It may be low when interest rates are high and the insurer expects to earn its required profit margin from investment income. It may be higher when interest rates are low, or if the insurer uses a cash flow plan, such as a paid loss retro, so little investment income is retained by the insurer.

In theory, the reserving actuary could collect the hundreds of needed plan combinations and match these with the appropriate experience and calculate the reserve. Or the actuary, to save a few months of work, might determine the average parameters by means of a regression analysis on historical data.

This is what Fitzgibbon and Berry have done. The regression analysis calculates the average retrospective rating plan parameters from past experience. In fact, this method is probably more accurate than might be achieved by collecting all the parameters actually used in each state and each policy year for each insured. Most companies allow their underwriters and agents substantial flexibility in rating workers compensation contracts. The pricing actuary may recommend a basic premium charge of 30% of standard premium, but the underwriter or salesperson may reduce the basic premium charge to 25% of standard premium. The pricing actuary's recommended parameters may not match the plan parameters that are actually used in practice. The reserving actuary needs to know the premiums that are actually charged, not the pricing actuary's indicated premiums. So the reserving actuary turns to the regression analysis, not to the pricing actuary's rate book.[4]

---

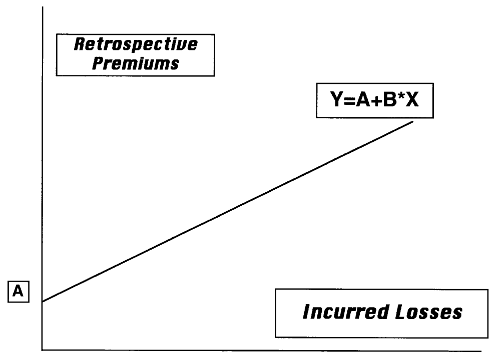
[4]How is it then, that Perkins and Teng manage to estimate PDLD ratios from the retrospective rating plan parameters in their formula approach? Moreover, they need to estimate more numbers than Fitzgibbon and Berry need to estimate, so how are they able to do this when Fitzgibbon and Berry found it unmanageable?

The answer is that the Perkins and Teng paper presents the method only. In practice, estimating the PDLD ratios from the retrospective rating plan parameters is exceedingly difficult, particularly if the company writes business in different states and for different types of insureds, if the company has changed its plan parameters over time, or if the company allows its underwriters and agents discretion in modifying the plan parameters to attract potentially good risks. Perhaps Ms. Perkins or Mr. Teng can elaborate on the relative ease or difficulty of estimating the PDLD ratios in various scenarios.

As pointed out by Robert Finger, the regression approach is not without its difficulties as well. Rating plan factors and aggregate loss ratios change over time, so a regression performed on historical data may not be equally applicable to current policies. Moreover, the observed values are actually the result of many changes at the individual plan level. The premium on individual plans is not a simple function of total incurred losses. For instance, premium may decrease on an adjustment when incurred losses increase, since there may be positive development on a claim that was already limited and negative development on claims that were below the per accident limit. See also Morell [10], which discusses this same issue.

FIGURE 1

FITZGIBBON'S METHOD



Graphical Representations

To see the difference between Fitzgibbon's method and the PDLD method, let us look at these procedures graphically. Fitzgibbon's method represents the relationship between the net earned premium[5] on the retrospectively rated book of business (as a percentage of standard premium) and the total incurred losses on this book of business (again, as a percentage of standard premium) as a straight line, as shown in Figure 1.[6] Algebraically, the straight line is $Y = A + B^*X$, where A is the constant factor and B is the slope factor.

One interpretation of this graph is as follows: if there are no incurred losses on this book of business, then the ratio of net premium to standard premium equals A. The constant factor A represents the basic premium percentage in the retrospective

[5]Net earned premium is earned premium after retrospective adjustments; see Feldblum [3].

[6]The figures on both axes of this graph are shown as ratios to standard earned premium. Alternatively, one could show both sets of figures as absolute dollar amounts. Berry uses ratios, though he shows the vertical axis as ratios of retrospective premium *returns* to standard premium. The three methods are equivalent.

rating formula.[7] As losses are incurred, and the loss ratio to standard premium increases, we move to the right and up along the straight line, and the net premium as a percentage of the standard premium increases. For each dollar of additional loss, the net retrospective premium increases by B dollars.

The slope factor B is the premium responsiveness for this book of business. The slope is not exactly unity, for several reasons. First, some losses exceed the loss limit, or they cause the retrospective premium to reach the maximum premium, even before the first adjustment, thereby reducing the slope of the line segment. Second, in some plans the minimum premium exceeds the basic premium. Third, a loss conversion factor and a tax multiplier are applied to the incurred losses in the retrospective rating formula, thereby changing the slope of the line segment. The combined effect depends on the "swing" of the plan. For plans with narrow swing, generally sold to small accounts, the slope would be less than unity. For plans with wide swing, generally sold to large accounts, the slope might be greater than unity.[8]

Projections versus Reality

The problem with this method, as Berry points out, is that it does not consider the emerging experience on the book of business itself. This emerging experience may differ from that expected from the graph for several reasons. First, the A and B factors are only estimated from the regression; they are not known with certainty. Moreover, they may vary from year to year. Second, the pattern of losses among the individual policies

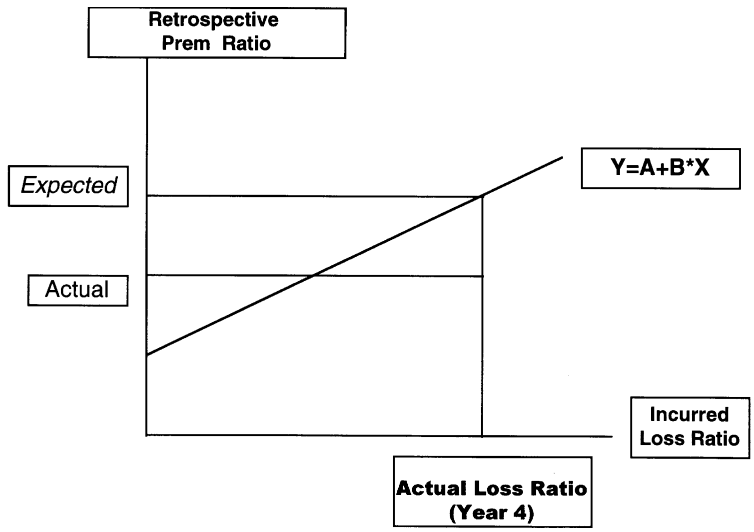
---

[7]Since the A factor is fitted by a regression on the aggregate book of business, it would not necessarily equal the basic factor on any particular plan.

[8]Fitzgibbon and Berry might say that this is not an exact interpretation of their regression line. Their regression line relates the *ultimate* loss ratio to the retrospective premium percentage. Their graph is not necessarily intended to represent the *movement* from no losses at policy inception to ultimate losses many years later. However, the purpose here is to highlight the contrast with the PDLD method, not to explain Fitzgibbon's method itself.

FIGURE 2

ACTUAL VERSUS EXPECTED RESULTS



affects the results. One large loss may have the same effect on the aggregate loss ratio as a dozen small losses. The effect on the net premium may differ because of loss limits and maximum premiums.

Suppose that after four years, the actual experience on this book of business shows less premium responsiveness than had been initially anticipated, as shown in Figure 2. The book of business is relatively mature after four years. The projection produced by this method does not change from year to year (as long as the incurred losses do not change), so it will continue to give an estimate of retrospective premium that is too high.

Berry's solution is to gradually discard this method, and to substitute a method that relies on the actual experience of the book of business (his "DR2" method). Initially, his reserve estimate relies entirely on this method. As time goes on, and more information becomes available from the actual book of business, he assigns progressively less weight to this method and more weight to his "DR2" method.

The Perkins and Teng Solution

Perkins and Teng transform Fitzgibbon's graph to solve this problem. Think of Fitzgibbon's graph in a slightly different fashion: as the movement over time of reported losses, net earned premium, and reported loss ratio. At policy inception, reported losses are $0, so the reported loss ratio is 0% and the ratio of net premium to standard premium equals A, the constant factor in Fitzgibbon's regression equation, or the Y-intercept in Fitzgibbon's graph.

There are two ways to interpret the chart in Figure 1. Only the first of these reflects the intentions of Fitzgibbon and Berry. The second reflects the PDLD method. The alternative interpretations are:

1. the graph relates the ultimate loss ratio and the ultimate retrospective premium ratio among different books of business or different years of experience, or
2. the graph relates the reported loss ratio and the net earned premium at different points in time for a single book of business.

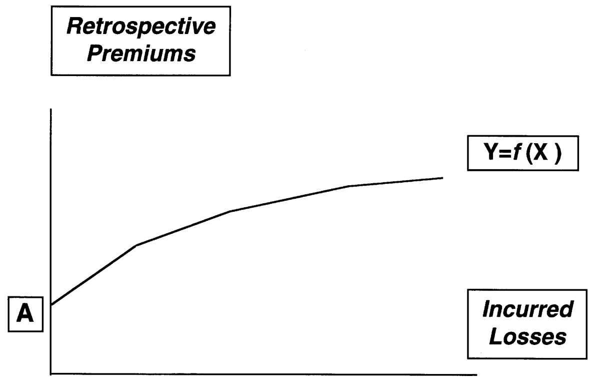
Decreasing Slopes

These two types of graphs seem similar. In truth, they look quite different. The first relationship is drawn by Fitzgibbon and Berry as a straight line. Actually, the curve is concave, as explained below, but a straight line is a close enough approximation for the majority of the curve.[9] The second relationship, however,

[9]It is a poor approximation at high loss ratios and at low loss ratios, though, where the maximum and minimum premium limitations flatten the curve. Fitzgibbon and Berry were aware of the approximation problems at the end points, and adjustments could always be made where necessary.

FIGURE 3

THE PERKINS AND TENG "PDLD" GRAPH



is not a straight line at all. Rather, it is a set of line segments, of steadily decreasing slope as we move to the right, as shown in Figure 3.[10]

The differing slopes of these line segments result from the loss limits and the maximum premiums in the retrospective rating plans. Most reported losses from policy inception until the first retrospective adjustment are rateable losses, which means that they are generally not truncated by the loss limit, and the retrospective premium is generally not capped by the maximum premium. The slope of the line segment is therefore close to unity. That is, for each dollar of reported loss, the insurer receives about a dollar of premium.

During subsequent periods, new reported losses stem from the emergence of IBNR claims and from development on known

[10]We use a series of line segments because retrospective adjustments are done annually, and the PDLD method reflects this by using line segments with different slopes for each adjustment period. In truth, a continuous concave curve better reflects reality, though it would not lead to a feasible reserving method.

claims. In workers compensation, for instance, new reported losses after the first adjustment may arise from the re-evaluation of a lower back sprain from a temporary total injury to a permanent total injury, with a corresponding re-estimation of the incurred loss from $25,000 to $500,000. This loss may be truncated by the loss limit in the retrospective rating formula, and the resulting retrospective premium may also be capped by the maximum premium.

This example is not contrived. On the contrary, it is quite common in workers compensation. Persons unfamiliar with industrial accidents often think of lifetime pension cases as quadriplegics or workers who have lost arms or legs in workplace accidents. Such injuries would be recognized immediately as high-cost, permanent total disabilities. These claims, which are recognized well before the first retrospective adjustment, are the ones that are most likely to be curtailed by the loss limits and maximum premium. This might lead some actuaries to think that the slope of the line segment in our graph should be flattest in the initial period.

In fact, accidents resulting in quadriplegia or the loss of arms or legs are rare. Most lifetime pension cases stem from sprains and strains and similar injuries that seem at first to be only temporary. After several years, when it becomes evident that the injured employee will not be returning to work, the claim is recorded as a permanent total injury and the benefit amount is re-estimated.[11]

We may state this as a general rule:[12]

1. *As a book of business matures, premium responsiveness on loss-sensitive contracts declines.*

---

[11] In the company at which the PDLD method was developed, fewer than 20% of claims that will ultimately be lifetime pension cases are recognized as such by the claims department at the first retrospective adjustment.

[12] As with any general rule, there are exceptions in particular instances.

In other words, as policies mature, a greater percentage of loss development is excluded from retrospective rating by the maximum premium and by the loss limit.

A second factor contributing to the declining slopes of the line segments is the overall increase in the reported loss ratio. It is not just that late-reported losses may be capped by the loss limit. Even a small claim will not increase the retrospective premium if the maximum premium has already been reached. Suppose the retrospective premium equals the maximum premium two years after policy inception. Then small claims reported during the first two years would have a premium responsiveness exceeding unity (because of the loss conversion factor and the tax multiplier), while small claims reported after the first two years would show a premium responsiveness of zero. We can state this second phenomenon as a general rule as well:

2. *At higher loss ratios, premium responsiveness on loss-sensitive contracts declines.*

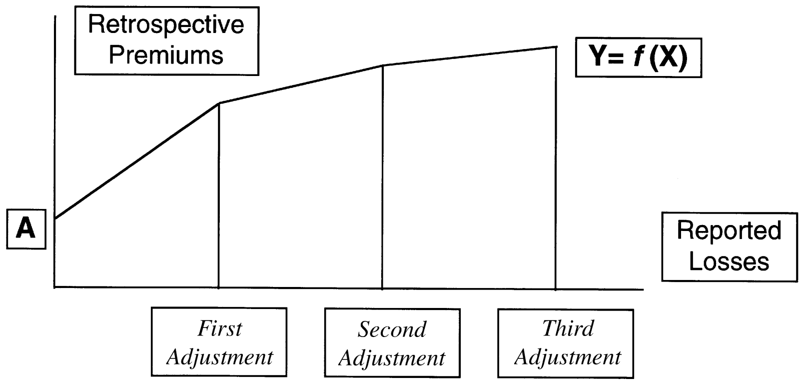
This last phenomenon relates to the overall loss ratio, not to the types of claims reported in any particular period. At higher overall loss ratios, more policyholders have reached their maximum premiums, so premium responsiveness is lower. Thus, it applies not only to the PDLD method, but to Fitzgibbon's method as well. That is, Fitzgibbon's graph is not really a straight line. In theory, it is a curve that is concave downwards, with steadily decreasing slope as the loss ratio increases.

Let us return to the PDLD method. At policy inception, the projected premium responsiveness graph is shown in Figure 4. Each line segment represents one period. The first line segment is from policy inception to the first retrospective adjustment, at about 21 months.[13] Subsequent periods are each one year long.

[13]The billing of retrospective premium generally lags the incurral of additional losses by about three months (on average) for an individual policy and by about nine months (on average) for a policy year. See below in the text for a full explanation of the lag times and effects that these may have on the observed premium responsiveness.

FIGURE 4

THE PDLD SEGMENTED GRAPH



The horizontal axis represents reported losses. For clarity, the graph is not drawn to scale. That is, the change in reported losses from policy inception to the first retrospective adjustment may be 50 percentage points or more in workers compensation, whereas the change in reported losses between adjustments at late maturities may be only a few percentage points. However, the graph shows all the line segments of equal length, so that the difference in their slopes can be seen clearly.

Actual versus Expected Experience

At the first adjustment, actual experience may differ in two ways from the experience that would be expected from the theoretical graph.

1. Actual reported losses may differ from the projected reported losses. For instance, at policy inception, the projected reported loss ratio to standard earned premium at 21 months may have been 55%. The actual reported loss ratio to standard earned premium at 21 months may be 50%.

2. The relationship between reported losses and retrospective premium may differ from that projected at policy inception. For instance, suppose that the Y-intercept in the graph is 20% and the slope of the first line segment is 1.100. Then for an actual reported loss ratio of 50% at the first retrospective adjustment, the ratio of net premium to standard premium is expected to be $20\% + 1.100 * 50\% = 75\%$. Suppose, however, that the actual ratio of net premium to standard premium at the first retrospective adjustment is only 72%.

These effects are shown in Figure 5 (not drawn precisely to scale).

- The projected experience at policy inception was for a reported loss ratio of 55% and a retrospective premium ratio of 80.5% [$= 20\% + 1.100 * 55\%$].
- For a reported loss ratio of 50% at the first retrospective adjustment, the graph projects a retrospective premium ratio of 75%.
- Actual experience at the first retrospective adjustment shows a reported loss ratio of 50% and a retrospective premium ratio of 72%.

The Perkins and Teng Assumptions

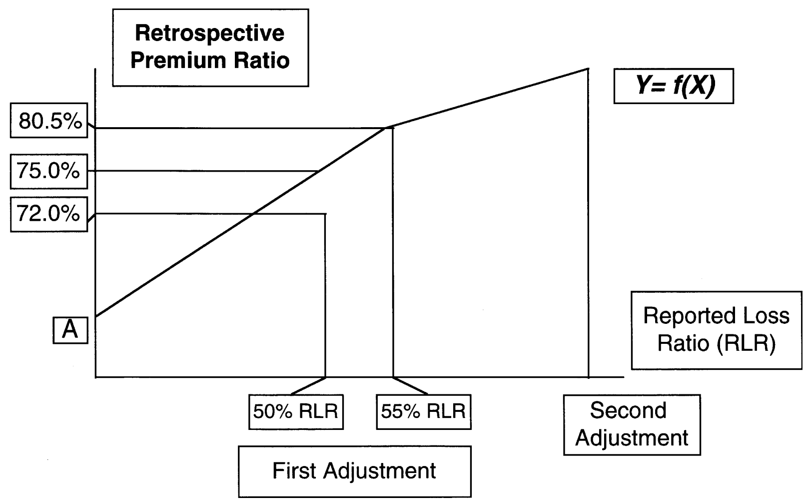
Two assumptions underlie the PDLD method. These are:

A. The premium responsiveness during subsequent adjustments is independent of the premium responsiveness during preceding adjustments.

B. The slope of the line segment depends on the time period, not on the beginning loss ratio or the beginning retrospective premium ratio.

FIGURE 5

PDLD METHOD: ACTUAL VERSUS EXPECTED RESULTS



We illustrate this for the first two line segments in Figure 5. Suppose the slope of the second line segment is 0.800. Think of the second line segment as an infinite number of parallel lines, all with slope of 0.800. At policy inception, we expected the second line segment to start at the point (55%, 80.5%) and to continue onwards with a slope of 0.800. As it turns out, the second line segment begins at the point (50%, 72%), but it still continues onwards with a slope of 0.800.

Compare the illustration with the two assumptions. We had expected a 75% retrospective premium ratio with a 50% reported loss ratio, but we actually get a 72% retro premium ratio. In other words, the slope of the first line segment is lower than we had originally expected. Nevertheless, we do not change our expectations for the slope of the second line segment. This is Assumption A.

The second assumption relates to when we change from the first line segment to the second line segment. From the appearance of the graph in Figure 5, one might think that we change when the reported loss ratio reaches 55%. That is not the meaning of the graph. Rather, we change at the first adjustment, regardless of the reported loss ratio at that time.

The manner in which the PDLD method solves Berry's problem should now be clear. Fitzgibbon's graph relates the *ultimate* loss ratio to the ultimate retrospective premium ratio. If actual experience differs from expected experience along the way, there is no way to get back on track. The PDLD method relates the *reported* loss ratio to the retrospective premium ratio. If actual experience differs from expected experience along the way, the next line segment begins at a starting point that corresponds to the actual experience.

The PDLD method quantifies the accrued retrospective premium asset in two steps.

1. Project the future loss development in each adjustment period.

2. Estimate the future premium revenue by the product of the future loss development in each period and the slope of the line segment in that period. The sum of these products is the accrued retrospective premium asset.

The PDLD method can be thought of as follows. The line segments represent a mountain being climbed, from the 0% reported loss ratio at policy inception to the ultimate loss ratio when all losses are settled. At each retrospective adjustment, the remaining part of the climb is shifted, both horizontally and vertically, but the shape of the climb is not changed (that is, the slopes of each line segment remain fixed).[14]

An Enhancement

In Figure 5, the first line segment begins at a point on the Y-axis representing the amount of retrospective premium when the reported loss ratio is 0%; that is, the Y-intercept is positive. This is the proper way to estimate the accrued retrospective premium asset. Perkins and Teng, however, have the first line segment passing through the origin; that is, the Y-intercept is 0. As a result, Perkins and Teng get a slope for the first line segment of 1.750. In fact, empirical data in their Exhibit 4, Sheet 1 for the most recent four quarters shows an average slope of 1.825.

Perkins and Teng's numbers combine two separate items: the basic premium ratio and the slope of the first line segment (when drawn properly). By failing to distinguish between these two elements, the method becomes less intuitive: how does one explain a slope of 1.825 or 1.750?

Similarly, the combination of these two elements leads to confusing interpretations. For instance, when discussing the cumulative premium development to loss development ratios (CPDLD), Perkins and Teng write:

> The CPDLD ratio tells how much premium an insurer can expect to collect for a dollar of loss that has yet to emerge. For instance, the first CPDLD ratio is 1.492, which means that each dollar of loss emerged provides the insurer one dollar and 49 cents of premium. The second CPDLD ratio is 0.556, which means that after the first retro adjustment, each additional dollar of loss provides the insurer 56 cents of premium.

[14] Actually, although the slopes of each line segment remain fixed, the length of the line segments may be changed. At each retrospective adjustment, Perkins and Teng re-estimate the losses expected to be reported in each subsequent period. These revisions, however, are generally minor.

The interpretation of the second CPDLD ratio is correct. The interpretation of the first CPDLD ratio, however, is mistaken. The first CPDLD ratio relates to all the expected losses from policy inception, at least according to the procedure in the Perkins and Teng paper.

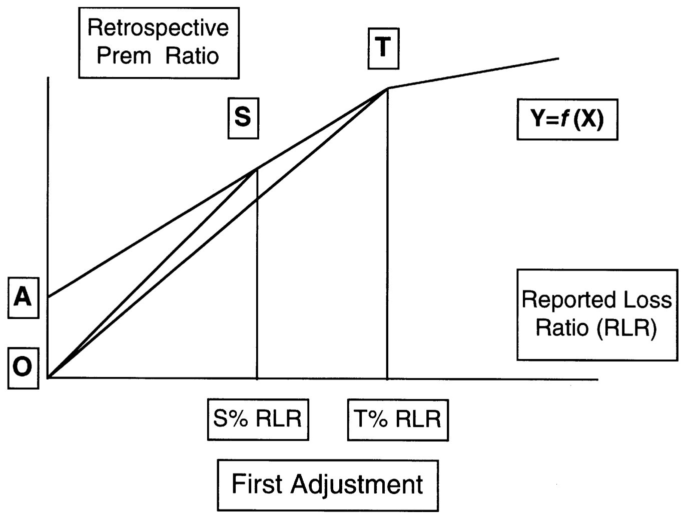
How should we interpret the 1.492 CPDLD ratio from policy inception to the first retrospective adjustment? Consider a relatively wide-swing retrospective rating plan: that is, a plan with high loss limits and maximum premiums. The amount of expected premium for each dollar of loss equals the loss conversion factor times the tax multiplier, minus a small amount for the non-rateable losses. This product may be about 1.200. The remainder of the first CPDLD ratio which Perkins and Teng calculate is the basic premium charge divided by the expected loss ratio (as a function of standard premium). For a basic premium charge of 25% and a standard loss ratio of 85%, this calculation gives $0.25 \div 0.85 = 0.294$. Adding 1.200 to 0.294 gives 1.494, which is about equal to the empirical figure which Perkins and Teng compute. In other words, when the basic premium charge is disentangled from the slopes of the line segments, the Perkins and Teng procedure corresponds intuitively with the actual retrospective rating formula.[15]

The failure to separate these two issues makes it harder for the actuary to analyze changes in the figures over time. For instance, what causes the steady rise in the slope of the first line segment from an average of 1.254 in policy year 1963 to an average of 1.825 in policy year 1992 (see Exhibit 4, Sheet 1 in the original paper)? Is it caused by a change in the average basic

[15]For a plan with significant loss limits or maximum premiums, the intuitive is analogous. The lower the loss limits, or the lower the maximum premium, the weaker will be the premium responsiveness, but the basic premium charge will be greater, because the insurance charge will be larger. These two effects will offset each other, since the insurance charge is calculated as the expected losses arising from the loss limits and maximum premiums.

FIGURE 6

LOSS REPORTING PATTERNS IN THE PDLD GRAPH



premium ratio, or is it caused by a change in premium responsiveness during the first period? These two factors are shown separately in the graphs drawn in this discussion, but they are not easily distinguished in the way that Perkins and Teng show their procedure.

This change could also be caused by a lengthening of the loss reporting pattern. This is an equally likely cause, and a graphical representation of it is illuminating.

In Figure 6, the basic premium ratio and the slope of the first line segment are not changed, but the percentage of losses expected to be reported before the first adjustment is decreased. That is, the expected ultimate loss ratio remains the same, but the expected reported loss ratio at the first adjustment decreases from T to S. The first line segment is therefore shorter, though it has the same slope. In the PDLD procedure, however, the slope of the first line segment appears to increase. That is, the slope from 0 to S is greater than the slope from 0 to T.[16]

Fortunately, it is simple to adjust the PDLD method to show the basic premium ratio separately from the true slope of the first line segment. One need only estimate the average basic premium charge as a ratio to the standard loss ratio, and then subtract this figure from the first CPDLD.

3. LOSS-SENSITIVE CONTRACTS AND UNDERWRITING RISK

Insurance serves several important economic functions, such as the transfer of the risk of financial loss from the consumer to the insurance company. Because of the unlimited nature of workers compensation benefits, a single severe workplace injury might financially impair a small employer. The transfer of this risk from the employer to the insurance company is a societal benefit of workers compensation insurance.

A societal downside to insurance is moral hazard. If there were no workers compensation insurance, then employers would take great pains to keep their workplaces as safe as possible, since they would shoulder any cost of workplace accidents. Insurance has two effects on employers' safety efforts. On the one hand, the loss engineering staffs of most workers compensation carriers can identify potential workplace hazards and improve employers' safety procedures. On the other hand, some employers become less concerned with employee safety, since they no longer bear all the costs.

An increase in moral hazard hurts both employees and employers. It hurts employees since workplace accidents may in-

[16]The effect is even more pronounced in the Perkins and Teng graph, which is drawn as a concave curve instead of a series of line segments.

crease. It hurts employers in numerous ways: there are training costs for new employees, work flows are interrupted, and workers compensation premiums increase to cover the higher loss costs.

Retrospectively rated contracts are an attempt to achieve the benefits of insurance while reducing the drawbacks. Employers are protected from the risk of large losses that might otherwise bankrupt the firm. But they still bear the cost of most other injuries, so moral hazard is kept low.

Insurance involves the transfer of risk from the consumer to the insurer. In retrospectively rated contracts, some of this risk is transferred back to the consumer. The NAIC has developed the loss-sensitive contract offset to the underwriting risk charges in the risk-based capital formula in order to reflect the fact that the risk on retrospectively rated contracts differs from the risk on prospectively rated contracts. Previous actuarial studies had not addressed this question, and the American Academy of Actuaries Task Force on Risk-Based Capital had little actuarial or statistical data to give to the NAIC.

The PDLD procedure, however, provides a direct answer. In fact, the Perkins and Teng paper sheds light on the potential limitations of both the risk-based capital loss-sensitive contract offset and the loss-sensitive contract exhibits in Part 7 of Schedule P.

Underwriting Risk

The insurance contract transfers the risk of random loss occurrences from the consumer to the insurance company. This risk is primarily process risk. For instance, suppose the consumer is an employer concerned with industrial accidents. The employer may estimate that there is a one in one hundred chance of a severe accident in his workplace this year. The primary risk that this employer faces is *not* that he has misestimated the probability—

that it is truly one in ninety, not one in one hundred. Nor is it the risk that the cost of such accidents may change, say from an average of $20,000 per accident to $25,000 per accident. Rather, the primary risk is that an accident will indeed occur this year in his workplace.

The risk to the insurance company is different. It is primarily parameter risk, not process risk. If the book of business is large enough, process risk effectively disappears. However, the risk that the probability of an accident is truly one in ninety, or the risk that the average cost of these accidents is truly $25,000, are serious concerns for the insurer. A relatively small error in the estimation of these parameters may wipe out the expected profits of the insurer.

Loss-sensitive contracts mitigate this risk for the insurance company. The insured is still protected against random large losses by the loss limit in the retrospective rating plan and by the maximum premium. Meanwhile, the insurance company is protected against the accumulation of more losses than expected, or a rise in the average cost per claim, by the responsiveness of retrospective premiums to incurred losses.[17]

Underwriting risk has two facets. Premium risk (or "written premium risk," in the NAIC risk-based capital terminology) is the risk that future premiums will prove inadequate to cover the future losses and expenses. This risk takes a variety of forms. For instance, there is a market risk that the competitive pressures of an underwriting cycle downturn will force premium rates below adequate levels. There is a regulatory/political risk that needed premium increases will not be approved or that new types of claims will be deemed compensable by the courts.

Reserving risk is the risk that the reserves held for accidents that have already occurred may prove inadequate. Once again,

[17] For a full discussion of the effects of loss-sensitive contracts on workers compensation reserving risk, see Hodes, Feldblum and Blumsohn [7].

this risk takes a variety of forms. For instance, there is the economic risk that a recession will cause injured employees to remain on disability for longer periods, since there may be no jobs to return to (workers compensation). Or there may be judicial risk, that courts or juries may grant higher awards to claimants (general liability).

Loss-Sensitive Contracts and Underwriting Risk

Loss-sensitive contracts reduce the risks to the insurer, since if losses are higher than expected, additional premiums are collected from the insureds. When the NAIC instituted its risk-based capital formula, which quantified the capital needed to guard against written premium risk and reserving risk, several large commercial lines insurers argued that a capital requirement that is appropriate for prospectively rated business is too high for retrospectively rated business, since the retrospective rating formula itself protects against unexpectedly high losses.

But how effective are these contracts in mitigating risk? In other words, how responsive are the premiums to unexpected losses?

If there were no loss limits or maximum premiums in the retrospective rating plans, the premium responsiveness would equal the product of the loss conversion factor and the tax multiplier. We term this 100% responsiveness, since the loss conversion factor generally covers loss-related expenses and the tax multiplier pays for premium taxes (and other state assessments) that depend upon the losses incurred or the premium collected. In other words, with 100% responsiveness, the insurer would get \$1.00 in extra premium for each \$1.00 in additional losses and loss-related expenses.

If there were no loss limits or maximum premiums in the retrospective rating plans, then the insurer would not be exposed to underwriting risk. If underwriting results are worse than expected, or if reserves develop adversely, the insurer would collect the full loss from the insured through retrospective premium adjustments. There remain some other risks, such as the credit risk that the insured will not be able to pay the retrospective premiums when they come due, but these risks are usually far smaller than the underwriting risk.

In practice, of course, there are loss limits and maximum premiums. Premium responsiveness is less than 100%. So the NAIC instituted a 30% loss-sensitive contract offset on primary insurance policies and a 15% loss-sensitive contract offset on reinsurance treaties. The loss-sensitive contract offset of 30% means that if the risk-based capital underwriting risk charge for a block of prospectively rated business is $\$X$, then the corresponding charge for the same book of business written on loss-sensitive contracts is $\$X*(1-30\%)$.[18]

In other words, the primary insurance loss-sensitive contract offset assumes (conservatively) that the premium responsiveness is only 30%. That is to say, for each \$1.00 in additional losses and loss-related expenses, \$0.30 of additional premium (on average) is collected.

The 30% figure was not based on definitive data because credible industry data on premium responsiveness was not available. The consulting firm Tillinghast/Towers Perrin conducted an industry-wide survey of 16 large writers of retrospectively rated contracts, and calculated an average premium responsiveness of 65%. The survey asked insurance companies how responsive they thought their loss-sensitive contracts were to unexpected loss emergence or unexpected loss development. The 65% was a rough average of the company estimates. Adjusting this figure downward for conservatism and for the potential

[18]For a complete description of the loss-sensitive contract offset in the risk-based capital formula, see Feldblum [5].

credit risk led to the 30% offset factor in the risk-based capital formula.[19]

In order to obtain industry data to more accurately estimate the loss-sensitive contract offset factor, the NAIC added Part 7 to Schedule P. The exhibits in this section of Schedule P are designed to allow the estimation of premium responsiveness on loss-sensitive contracts. These exhibits are a considerable advance over the information available previously, but they are far less useful than the information provided by reserving studies using the PDLD method.

In the future, insurance companies will seek to better quantify the effects of loss-sensitive contracts on underwriting risk, and state regulators will attempt more accurate estimations of the appropriate offset factor for these contracts. The study by Perkins and Teng highlights several areas that must be carefully considered.

Time Frames

The Schedule P Part 7 exhibits are the NAIC's attempt to quantify premium responsiveness, using the same method as Perkins and Teng, but with annual reporting of premiums and losses. The Perkins and Teng paper shows that the Schedule P results will be distorted in several ways, possibly to the extent that premium responsiveness will not be shown at all. Some of the problems can be corrected (in theory, at least) by means of the procedures in the Perkins and Teng paper; other distortions may be more difficult to remove.

---

[19]The rationale given by the Tillinghast study and adopted by the NAIC for the lower (15%) offset factor used for reinsurance treaties reflects the different types of loss-sensitive contracts generally used by primary companies and by reinsurers. The primary company retrospective rating plan adjusts the premiums billed for adverse loss experience. Some of these plans have extremely wide swings, in that the final premium may be as much as 100% more than the standard premium. Reinsurers generally use sliding scale commissions, in that the reinsurance commission remitted to the ceding company depends upon the loss experience on the book of business. Since the commission rate

The intended use of the Schedule P Part 7 exhibits is not explained in the Annual Statement Instructions, and few actuaries understand how these exhibits purport to quantify premium responsiveness. Let us first clarify the intention of this part of Schedule P with an illustration. We will then explain the problems with the statutory exhibits by a comparison with the Perkins and Teng paper.

The risk-based capital reserving risk charge is based on the loss reserves—both case and IBNR reserves—that are shown by the company's Schedule P, Part 2, minus Schedule P, Part 3. The reserving risk charge quantifies the capital needed to protect against the risk that these reserves may develop adversely in a worst-case scenario. The loss-sensitive contract offset factor reduces this capital requirement to reflect the additional premium that the insurer expects to receive in this worst-case scenario.

The dollar amount of adverse development of the loss reserve equals the dollar amount of adverse development of the incurred losses in Schedule P, Part 2. Part 7 of Schedule P displays incurred losses on loss-sensitive contracts and the corresponding adverse or favorable premium development relative to the adverse or favorable loss development.

An Illustration

An example should clarify this. Suppose we are given the extracts from Schedule P, Part 7A, Sections 2 through 5 shown in Table 1 (figures are in thousands of dollars). The actual exhibits contain more cells, but these extracts suffice to illustrate the quantification techniques. We wish to determine premium responsiveness from 24 to 36 months and from 36 to 48 months.

The sections of Schedule P, Part 7A, contain the following historical triangles, by policy year and valuation date, of experi-

---

is bounded below by 0%, and in many treaties it is bounded below by an even higher amount, the swing of the typical reinsurance treaty is much narrower than that of many primary retrospective rating plans.

TABLE 1

SCHEDULE P, PART 7A, SECTIONS 2, 3, 4, AND 5, SELECTED ENTRIES ($000)

Section 2	1994	1995	1996	1997
1994	1,000	2,200	2,400	2,500
1995		1,100	2,500	2,650
1996			1,200	3,000
1997				1,500
Section 3	**1994**	**1995**	**1996**	**1997**
1994	350	550	300	200
1995		400	600	450
1996			450	650
1997				500
Section 4	**1994**	**1995**	**1996**	**1997**
1994	1,500	3,150	3,300	3.350
1995		1,650	3,600	3,700
1996			1,800	4,200
1997				2,000
Section 5	**1994**	**1995**	**1996**	**1997**
1994	0	200	150	110
1995		0	210	155
1996			0	220
1997				0

ence on loss-sensitive contracts:[20]

- Section 2: Incurred losses and ALAE on loss-sensitive contracts
- Section 3: IBNR plus bulk loss and ALAE reserves on loss-sensitive contracts
- Section 4: Earned premium on loss-sensitive contracts

[20]For a full description of Schedule P, Part 7, see Feldblum [4].

- Section 5: Accrued retrospective premium reserves on loss-sensitive contracts.

This illustration is contrived. It is designed to show how Part 7 of Schedule P was intended to be used. We then examine how the Perkins and Teng paper explains the problems with this use of the Part 7 exhibits.

These exhibits are policy year exhibits, not accident year losses (as in Parts 2, 3, and 4 of Schedule P) or exposure year premiums (as in Part 6 of Schedule P). In Section 2 of Part 7, the incurred losses as of 24 months are about twice the incurred losses as of 12 months. This makes sense: the policy year 1994 incurred losses as of 12 months are those losses on policies written in 1994 that have occurred by December 31, 1994. These are about half of the policy year 1994 losses. By December 31, 1995, all of the policy year 1994 losses have occurred (though they have not necessarily all been reported by this time), so the 24 month figure is about twice as great as the 12 month figure.

The same is true for Section 4, showing the policy year earned premiums. By the end of the policy year, all the premiums have been written (though not necessarily collected), but only about half of these premiums have been earned.

This example assumes that the initial written premium for this block of business is the estimated ultimate net premium. Initially, there is no retrospective premium reserve. At the first retrospective adjustment, some premiums are returned to policyholders, since not all losses have yet been recorded, even though the insurer knows that there will probably be development on the reported losses. The accrued retrospective premium asset becomes positive after the first adjustment. For companies that charge initial premiums below the estimated ultimate net premium (for competitive reasons), the accrued retrospective premium asset will be positive from policy inception.

Quantifying Premium Responsiveness

Consider first the premium responsiveness from 24 to 36 months. Only policy years 1994 and 1995 in our illustration are mature enough to measure this.[21] For policy year 1994, losses develop from \$2.20 million to \$2.40 million from 24 months to 36 months, for a change of \$0.20 million. Premiums develop from \$3.15 million to \$3.30 million during the same time period, for a change of \$0.15 million. The premium responsiveness is \$0.15 million ÷ \$0.20 million, or 75%.

For policy year 1995, losses develop from \$2.50 million to \$2.65 million from 24 months to 36 months, for a change of \$0.15 million. Premiums develop from \$3.60 million to \$3.70 million during the same time period, for a change of \$0.10 million. The premium responsiveness is \$0.10 million ÷ \$0.15 million, or 67%.

As the estimated premium responsiveness from 24 months to 36 months, we might take the average of these two numbers. Alternatively, we might give more weight to the 1995 policy year, particularly if the rating plan parameters had changed in 1995.

For the premium responsiveness from 36 months to 48 months, only policy year 1994 is sufficiently mature to provide the needed figures. Losses develop from \$2.40 million to \$2.50 million from 36 months to 48 months, for a change of \$0.10 million. Premiums develop from \$3.30 million to \$3.35 million during the same time period, for a change of \$0.05 million. The premium responsiveness is \$0.05 million ÷ \$0.10 million, or 50%.

This is consistent with the Perkins and Teng paper. As reserves mature, premium responsiveness diminishes, since more losses are censored by the loss limit and more premiums are capped

[21] In an actual Schedule P, all earlier policy years would also show this relationship.

by the maximum premium. In addition, at later maturities, some retrospective rating plans are closed.

This example was designed to illustrate the intended use of the Schedule P exhibits; it would rarely be encountered in practice. The incurred losses here develop smoothly upward, and the premiums follow them equally smoothly. An adequately reserved company should show flat incurred losses along development periods, and similarly flat earned premiums. After all, these incurred losses include IBNR and bulk reserves, and the earned premiums include the accrued retrospective premium asset. The changes in incurred losses from period to period would be sometimes small and sometimes large, sometimes positive and sometimes negative, resulting primarily from random loss fluctuations. The changes in earned premiums from period to period would be equally variable, resulting again from random loss fluctuations as well as from censoring by the loss limits and capping by the premium maximums.[22]

We have two series of variable figures with means of zero, since favorable and adverse development are equally likely (in theory, at least). The ratios of these series will be even more variable, sometimes very high, sometimes very low, sometimes positive, and sometimes negative. These ratios may not tell us much about premium responsiveness.

Reported Losses and Billed Premium

As the Perkins and Teng paper shows, premium responsiveness does not deal with the relationship of changes in total earned premium to changes in total incurred losses. Rather, it deals with the relationship of changes in billed premium to changes in re-

[22]The date of recognition of additional losses or additional accrued retrospective premium reserves would add to the variability in the two series of changes, one of incurred losses and one of earned premiums. That is, the reserving actuary may recognize the potential increase in ultimate losses in one year, but he or she may not book the corresponding increase in the accrued retrospective premium reserves until some later time.

ported losses. Accordingly, Schedule P, Part 7 allows that analysis to be performed as well.

Section 2 of Part 7 shows incurred losses, and Section 3 shows IBNR and bulk reserves. The difference between Sections 2 and 3 represents reported losses.[23] Similarly, Section 4 shows total earned premiums, and Section 5 shows the net reserve for premium adjustments and accrued retrospective premiums. The difference between Sections 4 and 5 represents billed premium.

Let us repeat the premium responsiveness calculations using the simulated Schedule P, Part 7 exhibits provided above. For the premium responsiveness from 24 months to 36 months, we have data from policy years 1994 and 1995. For policy year 1994, reported losses develop from ($2.2 million–$0.55 million) at 24 months to ($2.4 million–$0.3 million) at 36 months, for a change of $0.45 million. Billed premium develops from ($3.15 million–$0.2 million) at 24 months to ($3.3 million–0.15 million) at 36 months, for a change of $0.20 million. Premium responsiveness from 24 months to 36 months is $0.20 million ÷ $0.45 million = 44.4%.

For policy year 1995, reported losses develop from ($2.50 million–$0.60 million) at 24 months to ($2.65 million–0.45 million) at 36 months, for a change of $0.30 million. Billed premium develops from ($3.6 million–$0.21 million) at 24 months to ($3.70 million–$0.155 million) at 36 months, for a change of $0.155 million. Premium responsiveness from 24 months to 36 months is $0.155 million ÷ $0.30 million = 51.7%.

Anticipated Emergence versus Unanticipated Development

These figures do indeed reflect reality, but is this reality related to the risk-based capital loss-sensitive contract offset factor?

---

[23] This is the same as the calculation of accident year reported losses as Part 2 of Schedule P minus Part 4 of Schedule P.

The risk-based capital reserving risk charge seeks to quantify the amount of capital needed to guard against unanticipated adverse development of loss reserves. For instance, if in a worst-case (but still reasonable) scenario, the company's reserves would develop adversely by $15 million, then the company should hold $15 million of capital to ensure its solvency.

The figures calculated in the preceding section measure the responsiveness of retrospective premiums to the emergence of anticipated losses. They do not tell us how responsive the retrospective premiums would be to the emergence of unanticipated losses.

An example should clarify this. Suppose we are examining the premium responsiveness from 24 months to 36 months on a workers compensation retrospectively rated plan with an average swing. Suppose that at 24 months the reported losses are $100 million, and the anticipated reported losses at 36 months are $120 million. The expected ultimate losses are $150 million.

From our hypothetical experience, we find a premium responsiveness for this period of 50%. That is to say, when reported losses increase by $20 million, the billed premium increases by $10 million. What are the implications for large and unanticipated adverse loss development, as envisioned in the risk-based capital worst-case scenario? For example, if the ultimate losses are re-estimated at $180 million at 36 months instead of $150 million, will the accrued retrospective premium asset increase by an additional $15 million, or 50% of the additional losses of $30 million?

Consider the real-world characteristics of the numerical example given above. The development of reported losses from $100 million to $120 million from 24 months to 36 months may be decomposed into several parts. One part is the lengthening of some temporary cases for another few months, or an increase in some medical benefits. This development is rateable, so premium responsiveness is high. Another part is the reclassification of some temporary total cases, such as lower back sprains, into lifetime pension cases, when it becomes clear that the injured employee will not be returning to work. Only some of this development is rateable, and the rest is truncated by the loss limits or the maximum premiums.

Large and unanticipated adverse loss development has a heavy proportion of this nonrateable element. The re-estimation of the ultimate losses from $150 million to $180 million may result from the re-classification of several back sprains as severe and permanent disabilities, or from a judicial or legislative decision that certain disease claims, or psychiatric claims, are compensable. These claims are generally large and they are paid over a long period of time. A large part of these claims may not be rateable.

The Perkins and Teng paper discusses these issues. As noted above in this discussion, the premium responsiveness depends on the maturity of the losses as well as on the average loss ratio in the block of business. The emergence of anticipated losses differs from the unanticipated adverse development of the expected losses in that:

- the anticipated losses are generally paid sooner than the unanticipated losses, and
- the anticipated losses generally represent a lower loss ratio than do the unanticipated losses.

Since the anticipated losses are generally paid sooner, they are accompanied by a stronger premium responsiveness. Since the anticipated losses are generally in a lower loss ratio environment, they are associated with a stronger premium responsiveness. In sum, the figures derived from the historical triangles in Schedule P, Part 7 may not be relevant to the scenarios with which risk-based capital is concerned.

Reserving Risk Offset versus Premium Risk Offset

The NAIC risk-based capital formula uses the same loss-sensitive contract offsets for reserving risk as for written premium risk: 30% for primary insurance contracts and 15% for reinsurance contracts. As the Perkins and Teng paper shows, the offset should be much higher for written premium risk than for reserving risk.[24]

For the written premium risk loss-sensitive contract offset, one must examine the first CPDLD factor in a Perkins and Teng study. However, one must separate the basic premium charge from the premium responsiveness to losses, or the offset factor will be overstated; see the discussion above for further explanation of this. Moreover, one must remove the effects of the loss conversion factor and the tax multiplier, which would also overstate the appropriate offset factor.

For the reserving risk loss-sensitive contract offset, one must examine the CPDLD factors at each maturity. One would then weight these CPDLD factors by the distribution of reserves at each maturity. As is true for the written premium risk loss-sensitive contract offset, one must remove the effects of the loss conversion factor and the tax multiplier.

The difference between premium responsiveness to the emergence of anticipated losses and premium responsiveness to unanticipated adverse loss development (or unanticipated adverse un-

---

[24]The appropriate figures depend on the types of plans sold by the insurance company. The indicated range of figures is wide, and the type of analysis used by Perkins and Teng must be applied to each company's book of business. For instance, for a workers compensation carrier selling wide-swing plans to large national accounts, the appropriate figures may be between 80% and 85% for the written premium risk loss-sensitive contract offset and between 60% and 65% for the reserving risk loss-sensitive contract offset. For a company selling narrow swing plans to small risks, the offsets are much smaller, extending down as far as the figures used in the NAIC risk-based capital formula. For a full analysis of premium sensitivity on plans sold to small accounts, see Bender [1] and Mahler [9].

derwriting results) can be significant. In the Perkins and Teng framework, the CPDLD's should be based on a book of business with an overall loss ratio equal to the worst-case year loss ratio in the NAIC risk-based capital scenario. Empirical data for such CPDLD's are not readily accessible. Approximations by curve-fitting techniques to the CPDLD's that are empirically available may have to be substituted.

Premium Billing Lags

Another section of the Perkins and Teng paper brings to light an equally significant problem with the Schedule P exhibits. When quantifying premium responsiveness, it is important to use corresponding premiums and losses. Premium billing occurs about 3 months after the retrospective adjustment. This implies that the premium billing lags the average loss occurrence by 3 to 15 months.

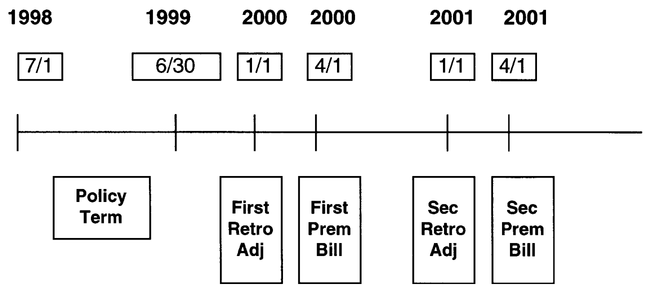
An example should clarify these figures. Suppose a policy is effective from July 1, 1998 through June 30, 1999. Retrospective adjustments are done six months after the policy's expiration and every 12 months subsequently. For this policy, the retrospective adjustments will be done on each January 1, starting with January 1, 2000. The resulting retrospective premium adjustment will be billed or returned to the policyholder on each April 1.

Each retrospective premium adjustment is driven by losses that are reported between 15 months and 3 months prior to the premium billing date. For this policy, losses reported between January 1 and December 31 affect the premium adjustment that will be billed on April 1. The schematic in Figure 7 shows this graphically.

The average lag between loss reporting and premium billing is 9 months. This is the lag used by Perkins and Teng. If one does not use any lag, as was the intention of the designers of Schedule P, Part 7, the results will be distorted. To see this most

FIGURE 7

PREMIUM AND LOSS DATES FOR RETROSPECTIVELY RATED POLICIES



clearly, suppose that:

- the retrospective premium billing is done on July 1,
- all losses occur on July 1,
- there is 100% premium responsiveness, and
- the annual incurred losses alternate between $1,000 and $0.

The Schedule P, Part 7, premium responsiveness test would show the following:

Year	1	2	3	4	5	6
Change in incurred losses	$1000	$0	$1000	$0	$1000	$0
Change in billed premium	—	$1000	$0	$1000	$0	$1000

The premium billing shows up a year after the loss occurs. In this example, there is 100% premium responsiveness, but Schedule P, Part 7, shows a -100% premium responsiveness.[25]

[25] If X denotes the change in incurred losses, and Y is the change in billed premium, than 100% premium responsiveness is represented as $Y = 100\% * X$. This policy's experience shows a line of $Y = \$1000 - 100\% * X$. In the actual calculations of premium respon-

In practice, simplistic examinations of premium responsiveness may yield regression coefficients which are negative or seemingly random. The reserving actuary may conclude that the data are incorrect, when the true problem is an improper matching of premiums and losses.

The Perkins and Teng paper shows a possible solution to our problem. Ideally, one should use quarterly data, with a 9-month lag between premium billing dates and loss reporting dates. Few insurers have this data, and the costs of obtaining such data far outweigh any benefits from these exhibits. As a practical alternative, one should use a 12-month lag in the quantification of premium responsiveness. A 12-month lag is not ideal, but it is better than no lag at all. Moreover, this requires no change in the exhibit completion process: the same exhibits may be used, but the quantification procedure would be modified.

4. CONCLUSION

Miriam Perkins and Michael Teng have put together an excellent paper, based on eight years of carefully examining the accrued retrospective premium reserves in workers compensation, general liability, and commercial auto for one of the country's largest writers of retrospectively rated policies. They methodically analyzed how premium responsiveness changes by reserve maturity and by aggregate loss ratio, and they systematically tested the lags between loss reporting and premium billing in the company's book of business.

The Perkins and Teng procedure is important not just for reserve projections but also for risk analysis. Our profession has much to gain as other actuaries learn the techniques presented by Perkins and Teng and use them to quantify the risk and rewards of loss-sensitive contracts.

---

siveness, of course, one does not use successive adjustments for a single policy or block of policies, but successive calendar years for the same adjustment for successive blocks of policies. The underlying concepts are the same, though the schematic becomes more complex.

REFERENCES

[1] Bender, Robert K., "Aggregate Retrospective Premium Ratio as a Function of the Aggregate Incurred Loss Ratio," *PCAS* LXXXI, 1994, pp. 36–74.

[2] Berry, Charles H., "A Method for Setting Retro Reserves," *PCAS* LXVII, 1980, pp. 226–238.

[3] Feldblum, Sholom, "Workers' Compensation Ratemaking," CAS Examination 5 Study Note, 1993.

[4] Feldblum, Sholom, "Completing and Using Schedule P," *Regulation and the Casualty Actuary*, NAIC, 1997.

[5] Feldblum, Sholom, "NAIC Property-Casualty Risk-Based Capital Requirements," *PCAS* LXXXIII, 1996, pp. 297–435.

[6] Fitzgibbon, Walter J., Jr., "Reserving for Retrospective Returns," *PCAS* LII, 1965, pp. 203–214.

[7] Hodes, Douglas M., Sholom Feldblum, and Gary Blumsohn, "Workers Compensation Reserve Uncertainty," Casualty Actuarial Society *Forum*, Summer 1996, pp. 61–149.

[8] Hope, F. J., Discussion of "Reserving for Retrospective Returns," *PCAS* LIII, 1966, pp. 185–187.

[9] Mahler, Howard C., Discussion of "Aggregate Retrospective Premium Ratio as a Function of the Aggregate Incurred Loss Ratio," *PCAS* LXXXI, 1994, pp. 75–90.

[10] Morrell, Roy K., Discussion of "A Method for Setting Retro Reserves," *PCAS* LXVIII, 1981, pp. 107–110.

[11] Uhthoff, D. R., Discussion of "Reserving for Retrospective Returns," *PCAS* LIII, 1996, pp. 187–189.