Property-Liability Insurer Reserve Errors: A Theoretical and Empirical Analysis

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Abstract

This article formulates hypotheses concerning property-liability insurer use of reserving errors from 1966 through 1979. A general theory is developed in which an insurer maximizes discounted cash flow subject to estimation errors and income smoothing constraints. Empirical tests suggest that the theory appears to be consistent with insurer behavior. Prior to 1972, reserving practices aided in reduction of tax bills subject to uncertain future claims costs. From 1972 through 1979, the causes of reserve errors appear to have altered somewhat. Reserve errors in the 1970s are related to taxable income and income smoothing, as well as inflation rate changes.

Introduction

The management and reporting of income by property-liability insurers have long been legitimate concerns of regulatory and investment communities. Regulators have been concerned that investors and policyholders have fair representations of an insurer's financial status. Investors logically have been concerned with the yield and relative riskiness of their investments. When levels of risk and return are obscure to investors and regulators, stocks may not be valued properly, policyholders may not pay equilibrium-level premiums, and the ability of the firm to pay claims arising in the distant future may be difficult to judge.

Detection of earnings manipulation is difficult at best, for the possibility of income management exists in every industry and differences in opinion develop over the proper measurement of income. The insurance industry is no different from other industries in its opportunities for income management. For example, the uncertainties involved in estimating future claim costs lead not only to reserve errors, but also to possible intentional income manipulation through the overstatement or understatement of reserves. Ultimately claim costs become known and the exact level of reserve errors is

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detected. Loomis (1984) reported that American Express received additional regulatory scrutiny in 1984 and was the defendant in an investor suit, resulting partially from reserving practices of an insurance subsidiary, Fireman's Fund, from 1978 through 1983.

Reserve errors often are viewed either as a deliberate attempt by management to manipulate reported earnings, or as the result of sheer misestimation. Why management would choose to create reserve errors and whether reserve errors contribute to the value of the firm have not been developed theoretically; nor has there been much discussion of tax incentives arising from the use of reserve errors. Most of this article addresses the issue of why reserve errors arise. Specifically, the purposes of this article are to develop a theory of reserving practices of property-liability insurers and to test the theory empirically using a larger sample than do many earlier studies. It will be hypothesized that an insurer has as its objective the maximization of cash flow subject to smoothing constraints and uncertainty.

Related Literature

The literature on reserve estimation is exhaustive. Salzmann (1984), Peterson (1981), and Skurnik (1973), among others, have detailed numerous acceptable methods of estimating reserves. Salzmann illustrates the effects of various estimation techniques on the reserve estimates reported to regulators and investors. The studies concentrated primarily on reserving techniques, however, and made little mention of the effects of misestimation. Forbes (1969) examined auto liability reserving techniques for a sample of insurers, suggested simulation to aid in selection of optimal reserving techniques, and discussed the impact of reserving on financial statement valuations. Forbes (1970) also studied the regulation of loss reserving and found the regulation in need of reform.

Anderson (1973) analyzed the effects of reserve errors on policyholders' surplus and found that reserve errors have a stabilizing effect on underwriting income. Balcarek (1975) and Ansley (1979) further related inadequate loss reserving to dismal underwriting experience in the 1970s. Ansley hypothesized that inflation was one of the major reasons for inadequate reserves in the 1970s.

The investigation of reserve errors was furthered by Smith (1980), who tested whether insurers manage loss reserves to smooth underwriting results. Smith found that the incidence of overreserving and underreserving errors was not random for a sample of property-liability insurers in the auto liability line. Weiss (1985) continued the studies of Smith for a sample of insurers underwriting auto liability policies. Weiss found that reserving errors were related to unanticipated inflation and also concluded that reserving errors stabilize reported income.

Forbes, Smith, and Weiss all concluded that reserve errors may be the result of a deliberate attempt by management to smooth income. Income smoothing as defined by Copeland (1968) is:

> the repetitive selection of accounting measurement or reporting rules in a particular pattern, the effect of which is to report a stream of income with a smaller variation from trend than otherwise would have appeared.

Similar definitions of income smoothing were proposed by Beidleman (1973), Ronen and Sadan (1981), and others in accounting literature, i.e., Koch (1981) and Moses (1986). Studies on income smoothing were performed by Scheiner (1981) and Dascher and Malcolm (1970) in the banking and chemical industries respectively. White's (1970) research is representative of many studies on the effects of income smoothing on earnings per share figures. The many empirical works were accompanied by the studies of Ball and Watts (1972) and Gonedes (1972), laying a theoretical base for the research on income smoothing by viewing earnings streams as stochastic processes. Lambert (1984) illustrated the conditions under which income smoothing arises as optimal equilibrium behavior.

The primary focus of insurance research on reserve errors has been to explain the effects of errors on reported income and policyholders' surplus. The focus of accounting research into smoothing in other industries has been the detection of whether smoothing behavior has taken place. Neither body of literature has addressed theoretically why a firm's management would choose to smooth reported income.

Development of a Theory of Reserve Errors

The Value-Maximizing Firm

Consider the case of a property-liability insurer whose business is to assume risk in return for premium payments from insureds. Premiums are collected at the beginning of a policy period and are earned with the passage of time. Claims are paid as they arise, with some claims remaining unpaid at the end of the year. Because some losses are incurred but not reported or adjusted by the end of the period in which related premiums are earned, regulatory authorities allow insurers to report estimates of future claim costs for tax purposes and for annual reporting purposes.[1] Assume initially that the insurer knows the level of unpaid claims or is able to estimate future claim costs accurately, the insurer is risk neutral, and there are no agency problems between the owner of the firm and compensated management.

The property-liability insurer calculates profits as a function of earned premiums, investment income, paid losses, and estimates of current claims to be paid in the future. This measure of reported net income is the basis for tax calculations. All income and expense sources in the hypothetical scenario are determinate. Given a property-liability insurer operating in the foregoing scenario and attempting to maximize the present value of cash flow, define:

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[1] The Tax Reform Act of 1986 requires insurers to report the present value of future claim costs on their tax returns, lessening the degree to which taxes are affected by reserve errors. Note that insurers still may be able to reduce taxes paid by recording even larger reserves.

P = premiums received in the current year
LP = present value of losses paid in the current year
L_e = present value of the estimate of losses incurred in the current year to be paid in the future[2]
L_a = present value of the actual amount of losses incurred in the current year to be paid in the future
I = present value of investment income received in the current year
t = tax rate

Assume that all premiums are received at the beginning of the year.[3]

In this scenario, the insurer is either assumed to know the ultimate claim costs or to be able to predict them accurately; thus, no reserve errors arise from the misestimation of future claim costs. Reserve errors may arise as the insurer tries to reduce its federal tax bill, for loss estimates are used in the determination of tax liabilities. By overestimating future losses attributable to current premiums, the insurer increases its reserves and incurred losses, and reduces its current tax liability. The insurer does not eliminate any taxes with reserve errors, but the insurer does postpone the payment of taxes until future periods when ultimate claim costs are known.

Define reserve errors as $e = L_e - L_a$, a function of actual and estimated losses to be paid in the future. Reserve errors may reduce cash outflows in the form of tax savings, however the reserve errors may not be created without a cost. Otherwise, insurers could manipulate reserve levels and reported income and avoid paying any taxes. One cost of the use of reserve errors is an increase in federal taxes if the IRS feels the insurer is manipulating earnings through reserves. In the past, a general guideline has been that reserve estimates could not exceed actual developed losses by more than 15 percent without IRS intervention.[4] Appeal courts allow the IRS to adjust loss reserve figures if the insurer cannot show the reserves are fair and reasonable estimates. In its checks of reserve levels, the IRS typically has used reserving methods that reduce overstated reserves but leave understated reserves unadjusted.[5] Excessive reserve estimates may lead to additional cash payments of taxes and to penalties.

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[2] Maximization conditions will be determined using discounted reserve levels required by the Tax Reform Act of 1986, instead of actual reserve levels permitted in earlier years. Theory development would be essentially unaltered by using undiscounted valuations of losses.

[3] Assuming that all premiums are received at the beginning of the year eliminates the need to deal with earned versus written premiums in the theory development. As many property-liability policies are written with premiums paid annually, or more frequently, the difference between earned and written premiums is relatively small. It was not felt that this refinement would affect the theory development.

[4] Tucker and VanMieghem (1981) report that the 15 percent guideline is no longer completely reliable.

[5] Notable IRS rulings include Hanover Insurance Co., 65 TC 715, dis(1 Cir; 5-13-76), Western Casualty and Surety Co., 65 TC 897, affirmed by (10 Cir; 1978) 41 AFTR 2d 78-667, 571 F2d 514, and Hanover Insurance Co. v. Commissioner (1 Cir; 1979), 43 AFTR 2d 79-1165, 598 F2d 1211. A summary of the court cases is found in Prentice-Hall (1987).

Other costs of reserve errors are more difficult to quantify, and may not measurably affect the cash flows of the insurer. Where reserves are overstated, income and surplus are reduced. The result could be the triggering of early-warning solvency systems for insurers whose surplus is impaired[6] and increased surveillance of publicly-traded insurers by the Securities and Exchange Commission.[7] Extra regulatory attention may be a cost few insurers care to incur. Additionally, policyholder confidence in the insurer may be diminished if surplus is reduced through overstated reserves.[8]

Shareholders of publicly-traded firms may be harmed if overstated reserves alter stock prices. Such an occurrence is possible if the market is unaware that managers are overstating reserves intentionally. Conversely, underestimates of reserves would lead to greater reported earnings at a cost of additional taxes paid by the insurer. There would be a real outflow of cash to pay taxes, and the underlying value of the firm to shareholders would be lessened.

Some costs of reserve errors are in the form of cash outflows while other costs are varied and difficult to quantify; yet, several generalizations may be made from the discussion of reserve error costs. Assume that large reserve errors, whether over or underreserves, carry a greater cost to the insurer than smaller reserve errors. In the case of regulatory bodies, large underreserving errors are more likely to trigger the early warning system, while large overreserving errors are more likely to alert the IRS. Large underreserving errors require payment of more taxes than do small underreserving errors, and are unlikely in the case where an insurer can accurately predict ultimate claims costs. Defining the cost of reserve errors as a function of the difference in the present value of estimated and actual cash flows required to pay losses, specify the error in the form of a general quadratic function,

$$\phi(e) = a_1(e) + a_2(e)^2, \text{ where } a_2 > 0.$$

The cost function will have the general shape depicted in figure 1. Inspection of figure 1 indicates that the cost of reserve errors may never be negative, hence the cost function is confined to quadrants I and IV. The portion of $\phi(e)$ located in quadrant I occurs when reserve errors are positive, or when $L_e > L_a$. In quadrant I, $\phi'(e) > 0$, and $\phi''(e) > 0$. In quadrant IV, $\phi'(e) < 0$ and $\phi''(e) > 0$. The function $\phi(e)$ located in quadrant IV corresponds to negative reserve errors arising when $L_e < L_a$.

Reserve errors affect reported income by altering reported underwriting gains and losses and by increasing or decreasing taxes to be paid. The present value of actual cash flow in the current year represents the intrinsic value of

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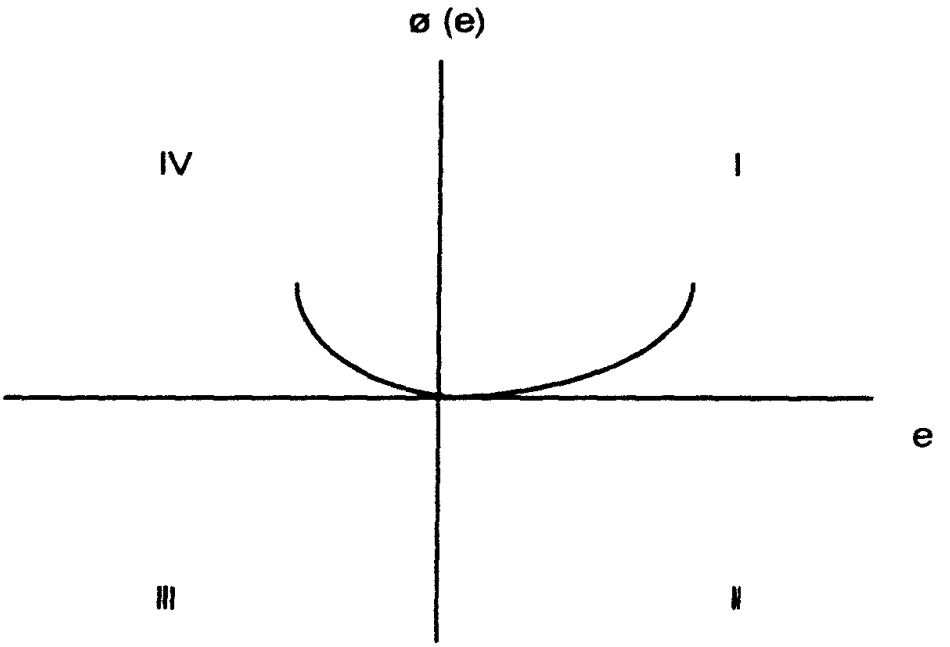
[6]The Insurer Regulatory Information System (IRIS) includes 11 tests of insurer solvency. Eight of the ratios involve either policyholders' surplus, reserve requirements, or liabilities. Each of these accounts is affected by reserving errors. For a fuller discussion of the system, see Breslin and Troxel (1978, p. 288).

[7]Note the increased regulatory attention devoted to Fireman's Fund in the recent wake of publicity given to its reserving practices.

[8]A. M. Best publishes insurer ratings which inspect reserve levels very carefully and are publicly available.

Figure 1

General Specifications of Reserve Error Cost Function



the firm to its shareholders, and also is affected by reserve errors. Letting ς_x be the present value of a sum for x periods, where x corresponds to the length of the loss development period, the present value of cash flows may be defined as

$$CF = [P - LP + I - L_a] - t[P - LP + I - L_e] - t(\varsigma_x)(L_e - L_a) - \phi(L_e - L_a) \quad (1)$$

The first bracketed term represents the present value of pre-tax cash flows; the second term refers to taxes paid on reported income in the current year; the third term refers to the discounted value of additional taxes paid (refunds received) in the future as a result of current over (under) reserves; and, the final term represents the cost of reserve errors. Rewriting, the equation becomes

$$CF = [P - LP + I - L_a][1 - t] + t(1 - \varsigma_x)(L_e - L_a) - \phi(L_e - L_a) \quad (2)$$

All cash flows, with the exception of actual claim payments and deferred taxes resulting from reserve errors, occur in the current period. Recall that reserve errors do not effect a permanent reduction in taxes to be paid, but simply defer the payment of taxes to a future period. The advantage of reserve errors is not the elimination of cash outflows as taxes; rather, it is the interest earned on funds as long as cash payments may be deferred. Equation (2) reflects the

fact that reserve errors are simply the result of accounting practices, and affect the firm's cash flow through deferral of tax payments.

The insurer whose objective is to maximize the present value of cash flows will estimate future claim costs in order to

$$\max_{L_e}(CF) = \{(P - LP + I - L_a)(1 - t) + t(1 - \varsigma_x)(L_e - L_a) - \phi(L_e - L_a)\} \quad (3)$$

The first order condition is

$$t = \phi'(e)/(1 - \varsigma_x).$$

Insurers will achieve a maximum discounted cash flow at the point where $t = \phi'(e)/(1 - \varsigma_x)$, or when the marginal tax savings equal the marginal costs of increasing reserves. If there are no costs to increasing reserves other than increased regulatory scrutiny or possible IRS penalties, the result can be interpreted as follows. As long as $t > \phi'(e)/(1 - \varsigma_x)$ the insurer has an incentive to overreserve, reducing its tax liability. When $t \leq \phi'(e)/(1 - \varsigma_x)$, the cost of a marginal dollar of overreserving errors exceeds the tax benefit received, and the insurer will halt its overreserving practices.[9]

In specifying the first order condition, $\phi'(e)$ is assumed to be positive. This assumption holds only when the insurer is overreserving. In this discussion, the use of underreserving errors ($\phi'(e) < 0$) has not been considered for the insurer. The result of underreserving errors is to understate losses, increase reported income, and increase taxes to be paid. It is intuitively obvious that an insurer with knowledge of future claim costs would not deliberately increase its tax liability, for the insurer would incur regulatory costs and a larger tax bill.[10]

It is important to note that there are means of reducing tax payments to the federal government other than the use of reserving errors. For tax years beginning on or before December 31, 1986, the Internal Revenue Tax Code (1988, §824) allows mutual insurers a tax deduction not allowed to stock insurers. The protection against loss (PAL) account generally allows mutual insurers to reduce taxable income by 1 percent of losses incurred or 25 percent of underwriting gain for a given year. There are limitations on the annual addition to the PAL account and ceilings are determined for the maximum amount the insurer may set aside in the account.[11] Likewise, a stock insurer may be able to reduce tax bills if the insurer is a member of a holding

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[9]Since the cost function is assumed to have a form $\phi''(e) > 0$, and the second derivative takes the value $-\phi''(L_{e,j} - L_{a,j})$, then $-\phi''(L_{e,j} - L_{a,j}) < 0$ and a relative maximum is assured.

[10]Grace (1984) and Cummins and Grace (1985) show that one occasion in which a value-maximizing insurer might use underreserving errors to maximize cash flows is a period in which the firm has tax loss carryovers from previous years. In order to use losses carried forward from previous years, the firm would need to report positive taxable income in the current year. Underreserving errors would allow the insurer to increase current reported income and offset the income by past losses that would expire in the future.

[11]The Tax Reform Act of 1986 has repealed the use of PAL accounts for tax years beginning after December 31, 1986.

company. To the extent that other companies in the group have deductions not available to the insurer, such as depreciation on long-lived assets, the insurer may not be as concerned with reducing taxes through reserving errors.

Income Smoothing

Smith (1980) and Weiss (1985) maintain that reserve errors may be a function of smoothing behavior by management, where smoothing attempts to minimize variability in earnings figures. In the absence of agency problems smoothing behavior would not be expected to persist, for managers generally are evaluated by shareholders and/or external factor markets. Unlike managers in most other industries however, managers of property-liability insurers also are accountable to insurance regulators and to policyholders.

Regulators are concerned with the overall return an insurer generates as well as with the variability of returns and policyholders' surplus. For example, IRIS requires calculation of a change in surplus ratio as a test of solvency.[12] Regulators are concerned that surplus neither decrease sharply in one year, nor increase rapidly over a year. As net income is one of the primary components of surplus changes, regulators implicitly are promoting smoothed surplus and smoothed earnings.

If managers of a property-liability insurer are to be regulated and evaluated in terms of rate of return, covariance with market returns, and variability of earnings, one might expect to see managers choose discretionary accounting practices that yield the highest rate of return with acceptable levels of earnings variability and market risk. Few practices offer more income smoothing opportunities than reserving practices. Management is able to increase or decrease reported cash flow by under or overreserving respectively. Management also has the ability to smooth out fluctuations in the underwriting cycle through the judicious use of reserving errors.

Income smoothing, whether as a result of agency problems or concern with regulatory requirements, does not alter the insurer's objective function from that specified in equation (3); however, smoothing behavior does constrain the objective function so that the current year's reported profits exceed previous years' profits while not exceeding future years' profits. If the requirement that current reported profits exceed past reported profits is binding, the insurer may underreserve to increase current year reported income. By underreserving, the insurer will be operating within quadrant IV of figure 1, where $\phi'(e) < 0$. A maximum will be achieved if $t \leq [\phi'(e) + y_1/(1 + y_1)]/(1 - \varsigma_x)$, where y_1 represents a Lagrange multiplier.[13] The insurer again will estimate reserve errors so the marginal tax savings equal the marginal cost of decreasing reserves. The term $y_1/(1 + y_1)$ may be interpreted as the effect on

[12] Target levels for the change in surplus ratio are: -10 percent $\leq$ change in surplus $\leq$ 50 percent. See Breslin and Troxel (1978, p. 288) for a fuller discussion of the ratios.

[13] A derivation of Lagrangean multipliers and Kuhn-Tucker conditions for constrained optimization is available from the author.

the optimal solution of requiring current year reported profits to exceed prior year reported profits.

Conversely if the insurer is bound to generate greater reported profits in future years than in the current year, it may resort to overreserving in the current year to reduce current reported income. By overreserving, the insurer is operating in quadrant I of figure 1, and $\phi'(e) > 0$. A maximum is achieved when $t \leq [\phi'(e) - y_2/(1 - y_2)]/(1 - \varsigma_x)$, or when the marginal tax rate is equal to the marginal cost of increasing reserves.

Misestimation of Reserves

In the previous two sections, it has been hypothesized that reserve errors may be created intentionally to smooth reported cash flow and to maximize actual discounted cash flow through the minimization of taxes. Both hypotheses tacitly assume that reserving errors are discretionary and are a conscious decision of management. Both hypotheses also assume that property-liability insurers know the cost of claims to be settled in the future with certainty; therefore, it is important to consider the uncertain nature of future claim costs in determining why reserve errors are created.

Consider the case of a property-liability insurer selling policies throughout the calendar year and paying losses as claims arise and are documented. At the end of the period, the firm knows what its earned premiums, investment income, and paid claims for the period are. It is difficult to determine the firm's liabilities for disputed claims, claims whose severity is yet to be determined, and reopened claims. Even less easy to determine are the insurer's liabilities for losses incurred for the period which may not have been reported. Because the losses have not been reported to the insurer at the end of the period, future claims against currently earned premiums can only be estimated. The problem is especially difficult when the firm underwrites long-tail lines of business.[14] Ansley (1979) provides a fuller discussion of inflationary impacts on reserving.

Because of uncertainty in claim costs, management will have more difficulty in selecting reserve levels that maximize firm value. Management's decisions will be based on its best estimate of future claims costs. To the degree that management misestimates the factors leading to ultimate claims costs (for example inflation and court judgments), reserves for an insurer operating in an uncertain environment will be different from reserves determined in the certainty case.

[14] Because policies such as auto liability and workers' compensation generate claims that may not be reported or paid until future periods, the insurer does not know with certainty all claim costs associated with a given policy at the point when premiums are earned. Such policies often are called long-tail lines of business, reflecting the probability that claims may be paid in the extended future.

The Model

Three hypotheses have been developed to explain the use of reserving errors by property-liability insurers. One can theorize that property-liability insurers use reserving practices to minimize federal tax payments, managers use reserving practices to smooth fluctuations in reported income, and/or reserve errors are the result of unintentional errors in estimation. Additionally, it has been asserted that reserve error behavior depends on corporate organization, i.e. whether the firm operates as a stock or mutual insurer and whether the firm is a member of a holding company. Without empirical testing, it is unclear which hypothesis or combination of hypotheses best explains insurer behavior.

The equation used to test the hypotheses is specified as:

$$\text{ERROR} = a + \beta_1 \text{TAX} + \beta_2 \text{SMOOTH} + \beta_3 \text{MISEST} + \beta_4 \text{MUTUAL} + \beta_5 \text{HOLDING} + \mu \quad (4)$$

The dependent variable is defined as ERROR = $[\text{Resest}_{i,j} - \text{Resdev}_{i,j+4}]$, where

$\text{Resest}_{i,j}$ = accident year estimate at the end of period j of unpaid claims arising from premiums written in period j for insurer i

$\text{Resdev}_{i,j+4}$ = developed claim costs on an accident year basis arising from premiums earned in period j for insurer i.

ERROR is the sum of reserving errors in auto liability, other liability, and workers' compensation lines for an insurer in a given year. Two specifications of ERROR were chosen for testing. ERROR1 divides ERROR by net premiums earned in auto liability, other liability, and workers' compensation lines of business while ERROR2 divides ERROR by $\text{Resdev}_{i,j+4}$. A positive value for ERROR denotes an overreserving error, while a negative value signifies an underreserving error.

All other variables used in estimation are comprehensive values for all lines of business written by the insurer in the sample year. It would be both uniform and useful to test reserving estimates for all lines of insurance underwritten. The availability of reserve values over long periods of time for lines other than the three chosen limits the data base. It is not believed that the limitation poses much of a problem, for omitted lines of business generally have shorter development periods; they would provide less opportunity for tax deferral or for smoothing; and, they would be subject to less misestimation.

TAX is a measure of the insurer's incentive to use reserve errors for tax deductions. The variable is the sum of current income to the insurer and is defined as:

$\text{TAX}_{i,j} = [\text{UI}_{i,j} + \text{II}_{i,j} + \text{Resest}_{i,j}]/\text{NPE}$, where

$\text{UI}_{i,j}$ = underwriting income reported in period j for insurer i for all lines of business

$\text{II}_{i,j}$ = total investment income earned in period j for insurer i, and

NPE = net premiums earned for all lines of business

A preferrable measure of income would exclude tax-exempt investment income. Data separating investment income into taxable and tax-exempt components are not available during the complete period studied.[15] Reported underwriting income is adjusted to reflect the taxable income figure considered by insurers in determining reserve levels. Underwriting income reported by property-liability insurers contains reserve estimates, hence the estimates of future losses are added back to taxable income to derive the decision variable used by insurers. According to the theory developed, insurers overestimate future claim costs as taxable income increases. Overestimation of claim costs reduces taxable income and the insurer's cash outflow in taxes. The sign of TAX is expected to be positive.

It was hypothesized that firms operated by managers may use both over and underreserving errors to smooth income variability. The hypothesis asserts that when current year earnings differ from prior earnings, the insurer will overreserve or underreserve to smooth current income. SMOOTH is defined as:

$SMOOTH_{i,j}$ = $[AVGUI_{i,j} + AVGII_{i,j}]/NPE$, where

$AVGUI_{i,j}$ = average of reported underwriting income for the three periods preceding period j for insurer i

$AVGII_{i,j}$ = average of total investment income earned in the three periods preceding period j for insurer i.

SMOOTH includes underwriting results for all lines of business and total investment earnings. If past average income is large, one would expect the insurer to smooth current income up by using underreserves. Conversely, when past average earnings are low, the insurer would smooth earnings down by creating overreserving errors. If insurers use reserves to smooth income, the variable SMOOTH is expected to be inversely related to reserving errors.

A variable representing inflation anticipations was included to determine if reserving errors are caused by an inability to foresee future loss developments. It has been advocated by Ansley (1979) and Weiss (1985) that reserve error misestimation is caused largely by unanticipated inflation in the costs of settling claims. In accordance with their findings, the variable chosen for the unanticipated inflation index was the variable used by Weiss. The variable MISEST is defined as:

$$MISEST_j = \left[\frac{\text{Average Weekly Wage Index}_{j+5}}{\text{Average Weekly Wage Index}_j}\right]^{1/5} - \left[\frac{\text{Average Weekly Wage Index}_{j-1}}{\text{Average Weekly Wage Index}_{j-6}}\right]^{1/5}$$

and represents the difference between actual inflation and projected inflation, as measured by changes in the weekly wage index. Actual inflation is

[15] In tax years beginning after December 31, 1986, incurred losses will be reduced by 15 percent of tax-exempt interest, effectively imposing a 15 percent tax on tax-exempt income. Also insurers will be subject to the corporate alternative minimum tax, for which tax-exempt income is a tax preference item and taxable. See the Tax Reduction Act of 1986 for further details.

measured by the geometric average of wage increases during the loss development period, while projected inflation is determined from past levels of wage inflation. Projected inflation is the geometric average rate of wage increases for the most recent loss development period.

Interpretation of the MISEST variable is altered from the interpretation given by Weiss. A positive value for MISEST does not necessarily imply that insurers do not anticipate inflation adequately, but merely that inflation during the current development period is greater than was the rate of inflation in a past development period. A negative value for MISEST implies that inflation in the current development period is less than inflation in a past development period.

If insurers perfectly anticipate changes in inflation, a coefficient of 0 would be expected for the MISEST variable, and misestimation due to inflation would not affect reserve estimates. If insurers are not able to anticipate changes in inflation levels correctly, an a priori relationship between the MISEST variable and ERROR is indeterminate. When inflation is increasing, firms increase reserve estimates in anticipation of higher costs to settle claims. Either underreserves or overreserves may result, depending upon the insurer's estimate of inflation. A similar result would occur in the event of decreasing inflation rates. A positive relationship between MISEST and ERROR indicates the insurer overestimated the change in inflation levels. A negative relationship indicates the insurer underestimated the change in inflation levels.

The variable $MUTUAL_i$ is a dummy variable assigned a value of 0 if insurer i is a stock company, and 1 if a mutual. The variable was included to test whether there is any significant difference in reserving practices for mutual and stock insurers arising from PAL accounts. The variable HOLDING similarly was included to determine whether members of a holding company reserve differently from non-holding company members. $HOLDING_i$ is a dummy variable assigned a value of 1 if insurer i is a member of a holding company, and 0 otherwise. Because both variables represent alternative methods to reserve errors of reducing cash outflows, their expected signs were negative.

Table 1

1979 Net Premiums Earned

Earned Premium Volume	Number of Sample Insurers
less than $50 million	10
$50 - $100 million	16
$100 - $200 million	12
$200 - $500 million	8
$500 million - $1 billion	11
over $1 billion	4

Source: *Best's Insurance Reports/Property-Liability edition*, 1980.

To test the equation, data were gathered from *Best's Insurance Reports/ Property-Liability edition* and from *Best's Reproductions of Convention Statements/Property-Liability edition* for a sample of 70 property-liability insurers selling auto liability, other liability, and/or workers' compensation policies from 1965 through 1979. After reducing the sample for insurers with incomplete data sets over the 15 years, the final sample contained 61 insurers of varying sizes. Sample insurers are listed in appendix 1. The range in net premiums earned for sample insurers is illustrated in table 1.

Estimation Results

Estimates of equation (4) were determined using ordinary least squares (OLS) on pooled cross-section and time series data.[16] To reduce problems of serial correlation for each insurer's data, autocorrelation coefficients were estimated separately for each insurer. The estimation equation was respecified as:

$$Y_{i,j} - p_i Y_{i,j-1} = \Sigma\, b_k(X_{i,j,k} - p_i X_{i,j-1,k}) \tag{5}$$

where p_i is the autocorrelation coefficient for firm i, $Y_{i,j,k}$ is the independent variable for firm i in year j, b_k is the regression coefficient for k independent variables, and $X_{i,j,k}$ is the independent variable k for insurer i in year j. Mean values, ranges, and standard deviations of the regression variables appear in appendix 2.

There is little reason to suspect that data are stable over the 15-year period in view of intensified underwriting cycles and increasing inflation rates, thus separate regressions were run for the periods 1966 through 1971 and 1972 through 1979. The period ending in 1971 was chosen as the cut-off point because of the extremity of underwriting cycles beginning after 1971. OLS results are reported in table 2 for 1966 through 1979, 1966 through 1971, 1972 through 1979, and for both specifications of the dependent variable

When taxable income as a proportion of net premiums earned increases by 100 percent from 1966 through 1979, the reserve error as a percent of net premiums earned increases by 9.7 percent. The results are similar for the periods 1966 through 1971 and 1972 through 1979, with TAX having coefficients of 4.9 percent and 11.3 percent respectively. In all specifications, TAX is of the expected sign and is significant in explaining reserve errors.

For 1966 through 1979 and the smaller period 1972 through 1979, SMOOTH is significant and bears the anticipated sign. Over the entire 14-year period, when average underwriting and investment income as a percent of net premiums earned in the three prior years increased by 100 percent, reserve errors as a percentage of net premiums earned decreased by 11.8 percent. Insurers underreserved and increased current income when prior average income was increasing. The coefficient was -21.6 percent from 1972 through

[16] A test for heteroscedasticity indicated that residuals were not equivalent across insurers. To reduce problems of heteroscedasticity, ERROR, TAX, and SMOOTH were divided by net premiums earned.

Table 2

Estimation Results Using the Ordinary Least Squares Estimation Technique

VARIABLE	Expected Sign	1966–1979	1966–1971	1972–1979
Dependent variable: SMOOTH1				
Constant	±	-.016 (-0.925)	-.086 (-3.546)***	.158 (2.548)***
TAX	+	.097 (4.748)***	.049 (2.492)***	.113 (3.155)***
SMOOTH	-	-.118 (-1.978)**	.058 (0.660)	-.216 (-2.677)***
MISEST	±	-.153 (-0.489)	1.349 (2.685)***	-3.043 (-3.043)***
HOLDING	-	-.017 (-2.648)***	-.014 (-1.937)**	-.020 (-2.137)**
MUTUAL	-	0 (0.027)	.004 (0.793)	-.003 (-0.423)
Adjusted R^2		.186	.240	.243
Dependent Variable: SMOOTH2				
Constant	±	-.057 (-2.452)***	-.199 (-4.511)***	.214 (3.652)***
TAX	+	.173 (6.257)***	.117 (3.185)***	.177 (4.292)***
SMOOTH	-	-.142 (-1.787)*	.242 (1.398)	-.324 (-3.635)***
MISEST	±	.467 (0.968)	3.784 (3.626)***	-4.709 (-4.296)***
HOLDING	-	-.019 (-2.237)**	-.020 (-1.475)	-.021 (-1.993)**
MUTUAL	-	-.001 (-0.191)	.007 (0.838)	-.008 (-1.030)
Adjusted R^2		.225	.284	.322

Values in parentheses represent T-statistics.

***significant at 1%

**significant at 5%

*significant at 10%

1979, implying perhaps greater smoothing. From 1966 through 1971, the coefficient of SMOOTH was positive, but insignificant.

One of the more interesting results was the relationship between inflation misestimation and reserve errors. Over the entire sample period, the coefficient of MISEST was small and insignificant. This is interpreted to mean

that over long periods of time, insurers were able to estimate inflation levels fairly accurately. For the period 1966 through 1971, the coefficient MISEST is 1.349. As inflation increased by 10 percent, reserve errors as a percent of net premiums earned increased by 13.49 percent and insurers overestimated the rate of inflation. As inflation increased by 10 percent from 1972 through 1979, insurers underestimated the rate of change inflation, and reserve errors as a percent of net premiums earned decreased by 30.43 percent.

For all time periods tested, HOLD is significant and inversely related to reserve errors as a percent of net premiums earned. A possible explanation for this is that other means of reducing taxes are available when an insurer is a member of a holding company. Interestingly, the MUTUAL variable was insignificant in every specification, indicating that stock and mutual insurers do not behave significantly differently in their reserving behavior.

Summary

The general theory of a discounted cash flow maximizing insurer that smooths income variations subject to estimation errors appears to be consistent with insurer behavior in the 1966 through 1971 and the 1972 through 1979 periods. Regression results indicate that from 1972 through 1979, reserving practices aided in the reduction of tax bills and the smoothing of earnings volatility, subject to uncertain future claim costs. During the period 1966 through 1971, reserve errors are unrelated to smoothing measures.

The results of this study are limited to the period 1966 through 1979. More recent experience with reserve errors would add to the understanding of the causes of errors. With decreases in the wage index during some years in the 1980s, an expanded period would shed new light on the role of inflation in the creation of reserve errors. The impact on reserving practices of the 1986 Tax Reform Act would be a further extention of this study into the 1980s.

Appendix 1

Sample Property-Liability Insurers

Stock Insurers

Aetna Casualty and Surety Company
Aetna Insurance
Allstate Insurance
American States
Argonaut Insurance
Bituminous Casualty
Continental Casualty
Continental Insurance
Employers Casualty
Federal Insurance
Fireman's Fund
Fremont Indemnity
Government Employees
Great American Insurance
Hanover Insurance
Hartford Accident and Indemnity
Highlands Insurance
Home Insurance
Insurance Company of North America
Maryland Casualty
New Hampshire Insurance
New Jersey Manufacturers
Northwestern National
Ohio Casualty
Old Republic
Pacific Indemnity
Pennsylvania Manufacturers Association
Reliance Insurance
SAFECO Insurance
St. Paul Fire and Marine
Security of Hartford
Southern Farm Bureau Casualty
Transamerica Insurance
Transit Casualty
Travelers Indemnity
United States Fidelity and Guaranty
United States Fire
Western Casualty and Surety

Mutual Insurers

American Mutual Liability
Country Mutual
Employers Mutual Casualty
Employers Mutual Liability
Federated Mutual
Grange Mutual Casualty
Harleysville Mutual
Liberty Mutual
Lumberman's Mutual Casualty
Merchants Mutual
Michigan Mutual
Motorists Mutual
National Grange Mutual
Nationwide Mutual
Pennsylvania National Mutual Casualty
Preferred Risk Mutual
Public Service Mutual
Sentry – A Mutual
Shelby Mutual
State Auto Mutual
State Farm Mutual Automobile
Unigard Mutual
Utica Mutual

Appendix 2

Summary Statistics

	ERROR1	ERROR2	TAX	SMOOTH	MISEST
			1966 - 1979		
minimum	-.829	-.537	-.151	-.239	.076
maximum	.352	.447	1.122	.508	.138
mean	-.022	-.031	.419	.058	.11
standard deviation	.077	.111	.194	.056	.019
			1966 - 1971		
minimum	-.240	-.371	-.151	-.040	.076
maximum	.172	.343	.981	.251	.127
mean	-.021	-.042	.321	.050	.096
standard deviation	.053	.107	.182	.047	.012
			1972 - 1979		
minimum	-.829	-.537	.178	-.239	.117
maximum	.352	.447	1.122	.508	.138
mean	-.022	-.022	.505	.065	.130
standard deviation	.094	.115	.161	.061	.006

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