Property-Liability Insurer Reserve Error-Motive, Manipulation, or Mistake

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Abstract

The literature provides various incentives for why insurers might mis-estimate loss reserves. The principal reasons are rational profit maximizing motives (minimization of taxes), manipulation (to smooth income, to avoid regulatory scrutiny or to justify premium rates), or mistake (the impact of general economic conditions or the types of business written). We simultaneously consider the extant theories of claim manipulation using the two main loss reserve "error" definitions found in the literature. The paper makes a number of additional contributions. We add new institutional constraints to the manager's ability to manage loss reserve estimates for solvency purposes. Using better measures of firm weakness we find little evidence supporting the conjecture weaker firms under-reserve to a greater extent than stronger firms. We also include a proxy for managerial efficiency and we examine whether IBNR reserves are the sources of claim manipulation. Overall we find that the principal motivation for loss reserving errors is not related to solvency manipulation or profit maximization motives, but rather seems that original estimated reserves are most likely unbiased forecasts of the sum of the eventual cash payments.

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> "Executives at the American International Group, the giant insurer, regularly made changes to the company's reserves to help meet earnings goals through much of the 1990's," *New York Times* May 9, 2005.
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> "'Certain but not all of the original characterizations resulted from transactions which appear to have been structured for the sole or primary purpose of accomplishing a desired accounting result,' AIG said," *New York Times*, March 31, 2005.

1. Introduction

Corporate accounting errors receive intense media attention. The highly publicized reports of accounting shenanigans by major corporations such as Enron, WorldCom, and Adelphia have led to major earnings restatements, large drops in firm market valuations, and sometimes criminal charges. Insurers were largely unscathed by the media spotlight. However, in May of 2005, Eliot Spitzer, the New York attorney general, filed civil charges against American International Group, Inc., its chief executive, and its chief financial officer for allegedly manipulating AIG's books to mislead shareholders, regulators, and policyholders.[1]

The civil charges against AIG result, in part, from the accuracy of the insurer's loss reserves. On Oct. 25, 2000, AIG announced a 9% increase in net income for the just-ended third quarter. The company's shares, however, dropped 6% due to investor concern over whether AIG under-reserved against future claims to meet current earnings expectations. Loss reserves are collectively the largest liability on a property-liability insurer's balance sheet, thus any under-reserving of losses will decrease an insurer's liabilities and boost its net income. In response to the drop in its share price, AIG allegedly initiated a finite-risk reinsurance transaction that shifted $500 million of expected claims to AIG from General Re, along with $500 million of premiums. AIG booked the premiums as revenue then added $500 million to its reserves. Although the finite-risk reinsurance deal received most of

[1] The complaint can be found at www.oag.state.ny.us/press/2005/may/Summons%20and%20Complaint.pdf

the media attention according to Spitzer's complaint, AIG also sought to manipulate loss reserves through unsupported "topside" or "top level" management adjustments.

Estimation of loss reserves necessitates considerable judgment. The establishment of loss reserves generally begins with the collection of information about an insurer's loss experience as well as information about the rest of the industry's loss experience (through rating bureaus like the Insurance Services Organization). Once this information has been compiled, the insurer's actuaries generate predictions about the insurer's future loss payments and expenses. Typically, actuaries recommend a range of loss reserves and then management chooses the actual loss reserves to be reported on the insurer's books. Estimates based solely on past claims may not yield accurate predictions of future claims, and thus reserves are likely to be revised as new information about claims arises.

Loss reserves are comprised of two components, the case reserve and the IBNR reserve. The case reserve consists of claim adjusters' estimates of the amount necessary to settle each claim when they are initially reported. Case reserves are periodically adjusted, as the uncertainty about ultimate payment is resolved. The IBNR reserve is, in contrast, an estimate for claims which have been incurred, but have not yet been reported to the firm. These are estimated by actuaries, and depending on the line of business there may be more or less uncertainty about how the claims will ultimately develop. Over the coverage period, the IBNR reserve should steadily decrease as the estimated level of still unreported claims falls. Naturally, considerable difficulties are encountered in estimating the likelihood, timing, and magnitude of reported claims, and even greater subjectivity is involved in estimation of claims that have yet to be reported.

The ultimate reported loss reserve is subject to significant managerial discretion and any resulting errors in the estimation of loss reserves are an important issue for regulators, shareholders, and policyholders. The difficulty in estimating the timing and size of future claims naturally results in some estimation errors. Inaccurate estimates of loss reserves result in the misstatement of liabilities and policyholders' surplus. Underestimating loss reserves (under-reserving) understates liabilities and overstates policyholders' surplus. In contrast, overestimating loss reserves (over-reserving) overstates a firm's liabilities and understates its policyholders' surplus. Reserve error problems are a good way of investigating a firm's decision making process. Ideally, we'd like to see firms making profit maximizing decisions, but to the extent that other reasons exist it exposes potential agency problems (Jensen and Meckling, 1976).

Given the uncertainties involved in estimating loss reserves it is conceivable reserve errors result from a firm's failure to take account of all the available information. Developments in litigation and costs can change significantly and give the perception that managers were "cooking the books" when, in fact, different expectations of loss development resulted from new information. It is also possible that reserve errors result from managers exercising discretion. Previous research hypothesizes that the motive for insurance company managers is to utilize loss reserve levels to maximize firm value through the smoothing of income (Anderson, 1973; Smith, 1980; Weiss, 1985; and Grace, 1990) and the minimization of taxes (Diacon et al., 2003; Grace, 1990; Gaver and Paterson, 1999; and Penalva, 1998). Other researchers suggest that insurance managers manipulate reserve levels for regulatory purposes, such as to appear healthy, to avoid regulatory scrutiny (Petroni, 1992; Beaver and McNichols, 1998; Beaver et al., 2003; Gaver and Paterson, 1999; Gaver and Paterson, 2004; Nelson, 2000; and Penalva, 1998) or to justify premium levels (Penalva, 1998; and Nelson, 2000). Additionally, studies indicate that reserve mis-estimation results from managerial mistakes related to the difficulty of determining an insurer's liabilities for reported claims, disputed claims, reopened claims, claims in which the severity has not yet been determined, and losses incurred but not yet reported (Ansley, 1979; Weiss, 1985; and Grace, 1990).

No research has included all the extant hypotheses in a single study. Some examine the motive of reserve estimation for organizational goals while controlling for possible reserve mis-estimation due to the difficulty of determining an insurer's liabilities. Other studies conclude that the objective of reserve estimation rests with one of the hypotheses without controlling for other rationales. For instance, Gaver and Paterson (2004) compare insurers reported IRIS[2] ratios to the values the ratios would have taken in the absence of reserve bias and conclude insurers manipulate reserves to avoid violating the NAIC's IRIS solvency boundaries. Understating loss reserves does enhance the probability of having the IRIS ratios within the usual range, but simply because the number of reported IRIS ratio

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[2] The Insurance Regulatory Information System (IRIS) is set of financial ratios has been used by National Association of Insurance Commissioners (NAIC) since the middle 1970s as a method of determining whether a firm should be subjected to some higher degree of solvency scrutiny. We will discuss this system further below.

violations decreases due to under-reserving does not necessarily indicate that the original solvency related motivation of the under-reserving was to avoid regulatory scrutiny.

A single or dual factor approach to estimating reserve error models is incomplete. If the other extant hypotheses are not recognized and controlled for in the study, the validity of the empirical results and the conclusions based on those results are weakened. Our objective is to employ all the existing rationales for why firms make reserve errors in a single model to better understand the contributing factors to reserve mis-estimation.

Our study of the various rationales for loss reserve errors is at the intersection of two established lines of research in accounting and property-casualty insurance. The accounting literature has endeavored to uncover the degree to which external incentives affect management's use of its discretion in reporting earnings. The practical importance of such an understanding is valuable to regulators, policyholders, shareholders, intermediaries, and rating agencies. Although practitioners and regulators feel that management's discretion to bias accounting numbers is pervasive and problematic, academic research has not revealed this to be the case (Dechow and Skinner, 2000). However, McNichols (2000) argues that much of the conflicting findings in academic research are due to the use of aggregate accrual models to measure accounting bias. McNichols recommends the use of specific accruals where the non-discretionary component is more readily available. Studies adopting this approach typically focus on a specific industry, such as property-casualty insurance, and use knowledge of institutional arrangements to characterize the likely nondiscretionary and discretionary behavior of accruals and provide greater insight and structure regarding the nature of likely correlated omitted variables. Second, in the property-casualty literature, researchers have made efforts to explain the extent reserve errors are based on the firm's profit maximizing incentives to minimize taxes, signal firm quality, smooth income over low and high income temporal states of the world, and respond to solvency and regulatory price incentives.

This paper differs from previous research on loss reserves in a number of dimensions. First, we jointly consider all the major rationales for reserve errors. Second, we re-examine the hypotheses regarding the motivation of firms with weak safety (in terms of solvency) incentives to intentionally under-estimate their loss reserves to conceal inadequate prices from regulators. Third, we verify whether insurers that write business in strictly regulated states and lines have the incentive to under-reserve to satisfy regulators. Fourth, we include in our regression models a measure that accounts for both reported IRIS ratios and estimated pre-managed IRIS ratios (i.e. IRIS ratios purged of any reserving error) to determine whether firms actually have the incentive to underestimate reserves to stay within IRIS solvency bounds. Fifth, we include a wider set of control variables including a revenue (or output) based DEA measure of a firm's economic efficiency. Sixth, we analyze the differences between under- and over-reserving firms and the factors that contribute to a firm consistently over-reserving. Finally, by targeting the loss reserve component subject to the most discretion, IBNR reserves, we conduct tests of discretionary behavior to determine whether IBNR reserves are the source of loss reserve errors.

Our approach is to examine the two main loss reserving error definitions described in the literature. We then look to see if our set of hypothesized variables are related to 1) whether the firm over-reserves; 2) whether the firm over-reserves for the entire sample period; 3) the magnitude of the reserve error; and 4) whether the IBNR is the source of loss reserves manipulation.

We find that there may be significant differences in our results depending upon which reserver error definition we employ. We make no recommendation as to which is the correct error definition in this version of the paper, but we need to point out that our results may call into question the robustness of the conclusions derived in the literature.[3] We also find that there is, in general, less support for the manipulation of reserves for solvency purposes. In fact, the coefficient on the index we created to measure the incentive to under-reserve is often of the wrong sign. In part, we believe that the regulators have more and better solvency tools which are less influenced by possible reserve manipulation. We also find, in contrast to the previous literature, that firms with a greater the percentage of premiums written in a highly price regulated environment are more likely to over-reserve for extended periods. Overall, the empirical evidence suggests that reserve errors are really error rather than discretion.

The remainder of the paper is organized as follows. Section 2 provides background information on reserve errors and reviews the extant literature on reserves. It also contains background information on the NAIC's solvency surveillance system and the construction

[3] We plan on looking at the question more carefully in a subsequent paper. One thing we do note is that one of our errors has a positive mean, while the other is essentially 0. If there is truly an error, one would expect it to have a zero mean.

of IRIS ratios that are purged of loss reserve error. Section 3 describes the hypotheses from the literature. Section 4 provides a description of our data and an explanation of our managerial efficiency and probability of insurer failure measures Section 5 explains our empirical methodologies and results. The paper concludes in Section 6.

2. Literature Review

2.A Background on Loss Reserving

Loss reserving, while seemingly esoteric, has important implications for insurers' pricing and competitive responses. For example, during the 1990s tort liability crisis St. Paul over-reserved (in an *ex post* sense) and when it realized that it had over-reserved, it released the reserves as profits on the income statement. Other insurers, thinking that St. Paul was reevaluating the size of medical malpractice risk, entered the market and cut prices. However, the risks really had not changed and the entrants had set prices below actuarial costs merely due to a perceived change in risk caused by St. Paul's actions.[4]

Concerns regarding insurers' proper reserve levels existed prior to the tort crisis of the 1990s. Forbes (1970) calls for greater regulation and disclosure of reserves presumably to mitigate insolvency. Others such as Weiss (1986) and Grace (1990) have pointed out that the relationship between reserves and taxes provides the IRS an incentive to monitor reserves to prevent corporate income tax avoidance.[5] A further concern reflects the policy-owners' and shareholders' understanding of how a company is managed. Systematic misreporting of reserves will influence the value of the firm as well as the ability of the firm to pay expected current liabilities and generate future profits.

Researchers have attempted to tease out the influences on firm's to over- or under-estimate loss reserves. Essentially there are five main, non-mutually exclusive hypotheses:

(1) Income Smoothing Incentives

(2) Tax Incentives

(3) Solvency Incentives

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[4] See Zimmerman and Oster (2002).

[5] In fact, one of the reasons insurers are not able to obtain tax deferred loss reserve status for catastrophes is the fear by the Department of the Treasury that other companies would be able to employ a catastrophic loss reserve to reduce current year tax payments. Since catastrophes are generally large, but few and far between (except in Florida in 2004), the insurer could conceivably deduct large amounts for reserves to cover a future catastrophe. Further, because one needs a relatively long time (say 20 years) to build reserves for catastrophes, the firm may be able to postpone its tax liability for some twenty years.

(4) Price Regulation Incentives

(5) Economic Conditions

Weiss (1985) examines the effects of income smoothing and the external economic environment on loss reserving. She investigated sixteen large automobile insurers over the period 1955-1975 and found evidence to suggest loss reserve errors stabilize underwriting results and that external economics factors, like unanticipated inflation and interest rates, also influence reserve mis-estimation.

Grace (1990) develops a general theory of a profit-maximizing insurer subject to estimation errors and income smoothing constraints. Consistent with her theory, she conducts an analysis of 61 insurers during the period 1966 to 1979 and finds some evidence that firms use loss reserve errors to reduce their tax liability. Cummins and Grace (1994) also found that the imposition of higher federal taxes caused firms to increase reserves.

A number of researchers Petroni (1992), Petroni & Beasley (1996), Penalva, (1998), Beaver, McNichols, and Nelson (2003), and Gaver & Patterson (2004) suggest that troubled insurers underestimate their reserves relative to other insurers. While each of the authors uses a slightly different approach to measure the solvency risk, this approach deserves some general discussion. Petroni (1992), for example, suggests that the greater the number of IRIS ratios that are outside of the NAIC defined bounds, the weaker the firm. In fact, most researchers suggest that an insurer is "weak" if four or more ratios (two or more if ratios that include reserve estimates are excluded) are outside the proper bounds.[6] Gaver and Patterson explicitly suggest that managers intentionally under-reserve to try to maintain their IRIS violations to no more than four to avoid regulatory attention.

Finally, Nelson (2000) examines the effect of price regulation on loss reserves. Her hypothesis is that insurers will under-reserve (essentially though discounting) so that they can offer more competitive rates. She finds that insurers operating in relatively stringent regulatory states (those with state made rates or prior approval statutes) discount reserves to a greater degree than other insurers.

2.B Loss Reserve Calculation

[6] There is some regulatory lore which suggests that this number of failures triggers more scrutiny from the state regulator, but as we discuss below, the failure of four or more IRIS ratios is not necessarily sufficient to trigger extra meaningful regulatory scrutiny.

There are two primary methods for calculating reserve errors in the literature. The first is what we call the Weiss (1985) or *W* error. This particular error has been employed in a number of studies (see e.g. Grace, 1990; Petroni and Beasley, 1996; and Browne *et al*, 2004) and is calculated as the difference between a given year's estimated reserves *and* the cumulative developed losses paid at a future point in time (Equation 1). The second error estimate is used by Kazenski, Feldhaus, and Schnieder (KFS) (1992), Penalva (1998), Beaver *et al*. (2003), and Gaver and Patterson (2004) which we denote as the *KFS* error. This error is the difference between incurred losses for firm *i* in a given year *t* and a future estimate of the same losses in year *t+j* (Equation 2).

$$W_{i,t}^{j} = Incurred\ Loses_{i,t} - Developed\ Losses\ Paid_{i,t+j} \quad (1)$$

$$KFS_{t}^{j} = Incurred\ Losses_{t} - Incurred\ Losses_{t+j} \quad (2)$$

In the *W* measure of loss reserve errors, the subscript *t* denotes the end of year valuation of the loss and the subscript *j* denotes some future year's accumulated loss payment. In Figure 1 the loss reserve is calculated as sum of the elements in the areas $\mathcal{A}_k$ (where k is either 3 or 5) less the sum of the elements in area $\mathcal{D}$. We examine both three-year and five-year errors. Incurred losses are those that are known to the insurer plus those that are estimated to have occurred. Developed losses paid are those losses actually paid at some future date. Thus the difference between incurred losses and what is eventually paid on these losses is the *W* error. Under-reserving is when incurred losses are less than paid losses and over-reserving is when the reverse is true.

The *KFS* error is slightly different. This error looks at the difference between the incurred losses in year *t* and a revised estimate of incurred losses in some future year *t* + *j*. In Figure 1 this would be the difference of the sum of the elements contained in the areas $\mathcal{A}_k$ less the sum of the elements in area $\mathcal{B}$. These measures are quite different as shown by the descriptive statistics in Table 1 Panel A and the graphical descriptions of the error's distributions in Figure 2. Two things to note from this table are the *W* measure has a positive mean and it is skewed in the positive direction. The *KFS* measure, on the other hand, has a mean closer to zero and, while more leptokurtic, appears not to be skewed. Thus, these two measures may behave differently. This is especially true for the three-year errors. As shown in Panel B of Table 1, the correlation among the three-year errors (.37) is quite low compared to the correlation among the five-year errors (.99).

In our analysis below we will employ both the *W* error and the *KFS* error for two time periods. The first will examine the errors at five years prior to "resolution" and the other will be at three years prior to "resolution". Schedule P of the National Association of Insurance Commissioner's Annual Statement requires insurers to describe their accident year loss development over a ten-year period. Over our sample, the percentage of losses paid at five years is approximately 65 percent, while at three years the percentage of losses paid is roughly 70 percent. Thus, as the time of resolution narrows, the firm has less discretion to alter reserves.

2.C Insurance Solvency Regulation

One of the major criticisms against the previous research is that the method for accounting for solvency regulation is simplistic. As mentioned above, the approach has been to examine whether the firm has failed a certain number of Insurance Regulatory Information System (IRIS) ratios. The National Association of Insurance Commissioners' (NAIC) IRIS system is a collection of analytical tools that provide state insurance regulators with a system for screening the financial condition of insurance companies operating in their state. The objective of IRIS is to select those companies that merit the highest priority in the allocation of the regulators' resources. The NAIC constructs a "usual range" for each of the IRIS ratios based on the experience of insolvent firms, and insurance companies with four or more IRIS ratios outside the usual range are given priority for further investigation (Troxel and Bouchie, 1995, p. 223). According to the received wisdom, if a company has four or more IRIS ratios out of bounds, then the state regulator will more carefully scrutinize the insurer's books. As Petroni (1992) acknowledges and Klein (1995) points out, the IRIS system is more complex. It does not force a regulator to act; it merely suggests various degrees of intervention. Thus a straight failure of four ratios is not an accurate description of how regulators examine firms. Second, in 1993 the NAIC instituted a more sophisticated solvency early warning system. This system, called the Financial Analysis and Surveillance Tracking (FAST), consists of 25 ratios that are publicly known.[8] FAST was developed, in

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[8] Grace, Harrington, and Klein (1998) list the ratios. However, there is no guarantee the NAIC still uses these same ratios to create their FAST system.

part, to reduce the effect of manipulation of accounting information that went into the IRIS ratios. Attached to each FAST ratio is a highly non-linear score.[10] Each insurer's overall score is then used, in part, to examine firms more closely. Grace, Harrington, and Klein (GHK) (1995) examine the predictive ability of the FAST system. They find that a logistic regression model using the individual FAST ratios plus a few addition variables performed as well or, better than the NAIC's FAST Score. We use a similar methodology (described more fully below) to capture the probability of failure of an insurer in a given year. This will more accurately reflect the incentives facing troubled firms.

To verify the contention that insurers manipulate their loss reserve to avoid violating four or more IRIS ratios, we construct a set of pre-managed IRIS ratios. The pre-managed ratios are the reported IRIS ratios which are purged of the firm's loss reserve error. Specifically, we calculate all twelve IRIS ratios for all firm-years (1989-1999) and use the NAIC bounds in effect in each sample year.[11]Table 2? presents a definition of each ratio, describes how each ratio is impacted by the loss reserve estimate, and lists the NAIC bounds for each sample year. As under-reserving increases reported policyholders' surplus, eight of the twelve ratios are improved by understating the loss reserve. One ratio (IRIS 11) is made worse by under-reserving, while two other ratios are unaffected by loss reserves (IRIS 2 and IRIS 5). For one ratio the effect of loss reserve error is indeterminate (IRIS 6).

Table 3? Panel A displays the violation rates of the reported IRIS ratios (*Reported* IRIS ratios). We see that the average number of IRIS ratio violations in 1.12. Table 4 Panel B reports the analogous findings after the IRIS ratios have been purged of the effect of reserve errors, using each of our definitions of reserve error (*Pre-managed* IRIS ratios). In general, there is an increase in the number of ratios violated using the ratios free of reserve

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[10] Thus the firm's total score can be written as a function of the scoring methodology for ratio *i* which is based upon the underlying ratio, e.g. $Total\ FAST\ Score = \sum_{i=1}^{25} Score_i(Fast\ Ratio_i)$. The FAST scoring methodology is not publicly available.

[11] The IRIS system traditionally consisted of eleven ratios, but a twelfth ratio was added in 1993. The pre-1993 "usual range" for the ratio added in 1993 is the 1993 prescribed bounds.

[13] A fifth hypothesis relates to the general economic conditions. In previous studies authors (see Weiss (1985)) use a yearly projection of unanticipated inflation. As an alternative, we control for differences in economic conditions across years using fixed effects estimation.

error. Understating the loss reserve enhances the probability of having the IRIS ratios within the accepted range. However, a reduction in the number of IRIS ratio violations due to under-reserving does not necessarily indicate that the mangers' original motivation was to make the firms appear solvent to reduce the potential for regulatory scrutiny. It is entirely feasible the under-reserving could have been driven by a completely separate rationale (i.e., managerial incompetence, constraints on the firm's future growth, income smoothing incentives, the difficultly of establishing loss estimates for long-tailed lines, etc.) yet manifest itself in fewer reported IRIS failures.

3. Received Hypothesis and Discussion

There are essentially four hypotheses from the literature that we focus on in this paper.[13] The first hypothesized motivation for discretionary behavior that we investigate is the smoothing incentives faced by the firm. According to the smoothing hypotheses, a firm will manage its earnings to keep long run profits in line with expectations. Specifically, if profits are unexpectedly higher (lower) in the present period, then the firm will over (under) reserve We define our first smoothing incentive variable in accordance with the literature (see e.g. Weiss (1985)) as the previous three year's average return on assets:

$$Smooth_t = \sum_{j=(t-3)}^{j=(t-1)} \left[\frac{Net\ Income}{Total\ Assets} \right]_j .$$

Our second smoothing variable (*Smooth 2*) is an indicator variable which takes the value one if the insurer experienced a loss in the immediate past year. In the event of a loss insurers, if they are smoothing, will over-reserve to level inter-temporal profits.[14]

Second, we look at the tax shield. The hypothesis here is that firms will have an incentive to over-reserve the greater the potential tax savings from having income classified as a reserve. We calculate this incentive as

[14] These two measures of smoothing are inadequate because the smoothing decision depends upon where the firm is relative to its desired level of earnings. Essentially, the smoothing variables do not consider current income relative to past years. However, current income is contemporaneously correlated with the reserving decision, so one should address this endogeneity problem to accurately test for smoothing. In a subsequent version of this paper we plan to examine this problem.

$$Tax\ Sheild_t^n = \begin{cases} \dfrac{(Net\ Income_t + Estimated\ Reserve_{t-1}^n)}{Total\ Asset_t} & if\ Net\ Income_t + Estimated\ Reserve_{t-1}^n > 0 \\ and\ 0\ otherwise. \end{cases}$$

where n = 3 or 5. The tax shield in the literature (see e.g. Grace (1990)) is calculated with the current year's estimated reserve; however, the tax shield value and the estimated reserve are contemporaneously determined. Thus we proxy for this year's reserve estimate by using last year's estimate to reduce endogeneity.

The third hypothesis we look at is the incentives created by the insurer's solvency prospects. Prior research has suggested that insurers have incentives to provide reported numbers that allow them to appear less risky and more capital adequate to avoid regulatory intervention. Coupled with this hypothesis is the notion that stronger insurer may signal their quality by taking a larger reserve which thereby reduces capital thus distinguishing themselves from weaker insurers (Penalva, 1998). Previous researchers used some indicator of solvency or "weakness" based upon the number of IRIS ratios failed or the incentive to manage these IRIS ratios. We employ three variables to examine different aspects of this hypothesis. The first is the probability of failure generated from a solvency prediction model (discussed in detail in section 4). The second is the incentive to under-reserve (IUR):

$$IUR_t = Sum\,of\ \text{Pre} - Managed\,Ratios\,Violated_t - Sum\,of\ \text{Re}\,ported\ IRIS\ Ratio\,Violations_t$$

We refer to this as the incentive to under-reserve because the firm could manipulate its reserves (by under-reserving to increase surplus) to violate fewer IRIS ratio test bounds. The reported IRIS ratio failures would be observable to the regulator. However, the pre-managed IRIS ratios are those ratios which would be outside the bounds given no reserving error. Thus, to the extent that under-reserving is being driven by the desire to avoid regulatory attention the difference between the pre-managed IRIS violations and the IRIS violations will be significantly related to the degree of under-reserving.

After 1993 the Financial Analyses and Surveillance Tracking (FAST) system was being employed by the NAIC. In addition, in 1994 risk based capital was introduced. Thus, regulators had other types of solvency information to use and, arguably, the attention should shift away from a focus on IRIS ratios. Therefore, prior to 1993, IRIS ratios arguably would matter more to regulators and thus to insurers' incentives to manage their reserves. The third solvency related variable is a dichotomous indicator variable, set equal to one for all years prior to 1993, interacted with IUR to account for the change in solvency surveillance that occurred starting with the 1993 reporting year.

The fourth hypothesized motivation for discretionary behavior discretion is the effect of regulation. Nelson (2000) hypothesized and found evidence that firms will under-reserve in more heavily regulated lines. We examine this incentive to under-reserve by looking at the percent of premiums written in more heavily regulated lines (auto, homeowner, and workers compensation) in those states with prior approval laws.[15] Prior approval statutes require insurers to seek the regulator's approval prior to introducing a new rate However, we believe that a different hypothesis is needed for this incentive. When regulators set prices strictly they want to make sure the consumers obtain the lowest price under the law. The regulated rate may be below the competitive price and thus insurers react by increasing their reserves to reduce the effect of the rate suppression. By raising reserves insurers effectively signal to the regulators that the regulated price will cause the firm to sell at a loss.

We also add one new hypothesis to the literature that the effect of managerial quality or managerial efficiency influences the decision to over- or under-reserve. More specifically, more efficient firms will be less likely to mis-reserve all other things held constant. Over-reserving caused by non-profit maximizing rationales comes at a cost to the owners of the firm. Thus, to the extent managers are acting efficiently they should take into account the costs of under- or over-reserving.

4. Sample and Data

We use data from the NAIC's annual statement, from 1989 to 1999. This panel has some 10,900 firm years. Also, because we employ lagged terms (especially for our income smoothing variable), the size of the data set is reduced to approximately 8900 firm years. We also delete firms if the data do not allow us calculate the efficiency measure (which is relatively data intensive), the probability of failure measure, or if the firm had zero reserves. Our final sample consists of those firms which account for approximately 73 percent of the direct premiums written and 71 percent of total industry assets over the sample period. We have a much larger data set than most previous studies. The major and most important

[15] We use the description of states with prior approval laws found in Harrington (2002).

difference between Statutory Accounting Principles (SAP) and GAAP provision is that losses are not discounted, which makes the firm appear more conservative. SAP thus has the effect of biasing our results against finding large errors, so to the extent we find evidence of systematic errors, our results will be robust.

4.A Variable Construction

Firm efficiency, the manger's ability to marshal resources to generate the most profit or to minimize costs, would seem to have an effect on a firm's decision to manipulate reserves. Grace and Leverty (2005) show that firm efficiency can proxy for management ability of the simplest sort, i.e., can the management pay inputs at their marginal product and produce the proper output mix. Choosing to increase reserves rather than selling more business may generate opportunity costs. More specifically, firms that under-reserve may be generating an opportunity cost to the owners which could be picked up by our measurement of firm efficiency.

In this version of the paper, we calculate and use a single measure of firm efficiency: revenue efficiency. Revenue efficiency is calculated using frontier efficiency methods (Aigner, Lovell, and Schmidt (1977) and Charnes, Cooper, and Rhodes (1978)). The modern frontier efficiency approach is based on the recognition that some firms will not be as successful as others in meeting firm objectives. The technique measures the performance of each firm relative to "best practice" frontiers consisting of the dominant firms in the industry. A firm is fully efficient if it lies on the frontier and inefficient if it is not on the frontier. We estimate efficient revenue frontiers giving measures revenue of efficiency for each firm in our sample.

Revenue efficiency is the ratio of the revenues of a given firm to the revenues of a fully efficient firm with the same input vector and output prices. Thus, in this paper revenue efficiency can be thought of in two ways. First, it can be thought of as an indicator of managerial quality. For example, does the manager generate the most revenues possible for the firm? Second, the efficiency measure can also be an indicator of how well the manager employs the firm's capacity. More revenue efficient firms, for example, may be able to sell more insurance because they are able to allocate resources within the firm in a more productive manner than less efficient firms.

To estimate frontier efficiency the Data Envelopment Analysis (DEA) methodology is employed. DEA is a linear programming technique that compares each firm in the industry to a "best-practice" efficient frontier (see Appendix A for a description of DEA and Appendix B for a explanation of the inputs and outputs utilized in the linear programming model). The program forms a convex combination of efficient firms for each firm in the sample. DEA is appropriately named since it truly envelops the entire data set, making no accommodation for random noise outside the control of each firm. Any departure from the frontier is measured as inefficiency. A firm is fully efficient (efficiency of 1.0) if it lies on the frontier and inefficient (efficiency < 1) if it is not on the frontier, which means that its outputs could be produced more efficiently by another firm or firms. [16]

Figure 3 shows the distribution of the revenue efficiency across all years. Note that there are some firms that are fully revenue efficient (RE = 1), some that are truly inefficient (RE approximates 0), and others spread through the interval. These results are consistent with other studies employing revenue efficiency (see e.g. Cummins and Xie (2005)).

Prior definitions of financial distress in the property-liability insurance literature rely on IRIS ratios.[18] Petroni (1992) and Beaver, McNichols, and Nelson (2003) define financial distress as a firm with one or more IRIS ratio, (excluding those ratios that involve reserves) outside the NAIC "usual range". Neale, Habegger, and Peterson (2003) define general financial distress as four or more IRIS ratios outside the NAIC defined range. As we discussed in Section 2, the reliance on IRIS ratios in defining financial distress is potentially problematic since it does not force a regulator to act. Our definition of financial distress does not rely solely on the violations of IRIS ratios.

In contrast, we attempt to simulate the NAIC solvency screening system to obtain the firms that are truly subject to regulatory scrutiny. Accordingly, we use logistic insolvency prediction models to construct a probability of failure for each firm in each year prior to our loss reserve error variables (i.e. for the years 1988-1998). The explanatory variables in our regression model are a mutual firm indicator variable, a size variable (log of assets), and

[16] Leverty (2005) describes in detail the method we employ to calculate the efficiency measure. We use the particular efficiency measure that is most related to external measures of a firm's market value. Because most companies in our sample are not publicly traded, the efficiency measure can also be thought of as a proxy for market value.

[18] Approximately 11% of companies fall outside the usual range on four or more ratios for any given year (see NAIC Insurance Regulatory System, 2002).

factor scores of IRIS and FAST ratios as shown in equation (3).[19] The use of a size variable and a mutual indicator variable is consistent with the extant literature on property-casualty insolvency predictions. The FAST system is used in addition to the IRIS ratios because the FAST system provides more accurate solvency predictions than the IRIS system (Grace, Harrington, and Klein, 1998; and Cummins, Grace, and Phillips, 1999).

$$I_{jt} = \alpha_0 + f(Size_{jt}, Mutual_{jt}, Ratio_{jt}) + \varepsilon_{jt} \qquad (3)$$

For insurer *j* and data year *t*, I_{jt} is the unobserved propensity to fail subsequent to year *t*,[20] $Size_{jt}$ is the log of total assets, $Mutual_{jt}$ equals 1 if insurer *j* is a mutual and zero otherwise, and $Ratio_{jt}$ is a vector of IRIS and FAST ratio factor scores.

Figure 4 shows the average number of IRIS ratio failures versus the probability of failure in year *t*-1. Note that these measures of firm weakness look different over our time period. The probability of failure (measured on the right Y axis) seems to be relatively stable, while the average number of IRIS ratios failed increases and decreases as does the percentage of firms that fail four or more ratios each year. We also observe that the average pre-managed number of failed ratios is also higher than the average number of reported ratio violations.

4.B Descriptive Statistics

Table 4 shows the sample descriptive statistics. In our empirical section we employ a number of control variables. We do not discuss them in great detail, but these include concentration by line and by state, size, and growth in terms of net premiums written. We also include organizational form variables to control for the incentives inherent in different ownership structures that may affect reserve management behavior. Further, we control for the observation year. We have a relatively large number of mutual companies (19.2 percent) and a relatively small number of Lloyds, Risk Retention Groups, and Reciprocals. The stock form, however, dominates the sample. Sixty-seven percent of the insurers are stock companies. Most firms are members of a group (75.4 percent); a small percentage is direct writers (15.2 percent); and a small percentage is publicly traded (13.4 percent). The types of

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[19] There are ratios that are common to both the IRIS and FAST systems, thus shared ratios are used only once. In addition, factor analysis on the IRIS and FAST ratios is used to eliminate the multicollinearity among the ratios in each year.

[20] A three-year prediction period for insurer insolvency is utilized. Insurers are classified as insolvent if it was subject to formal regulatory proceedings for conservation of assets, rehabilitation, receivership, or liquidation.

business written are broken down into four broad categories.[21] The average firm has 26 percent of premiums written in commercial short tail, 36 percent in commercial long tail business, 31.4 percent in personal long tail lines, and 10 percent in personal short tail lines.

In terms of concentration, the average firm has a line of business Herfindahl Index of about .35, which translates to an average of 3 lines of business. For the geographic Herfindahl, the index is approximately .5 indicating that the average firm operates in two states. The average firm size is $558 million in nominal dollars and is approximately 20 percent revenue efficient. The average firm's one year growth rate is approximately 24 percent.

The average firm has a tax shield as a percent of net premiums that ranges from about 50 to 90 times net premiums earned. These relatively large numbers are due to outliers as the median is 3.34 for the three year error and approximately 4.4 for the five year error. The incentive to smooth income measured by the three year average rate of return on assets is approximately 2.6 percent. Nineteen percent of our sample had negative net income in the previous year. The average firm has approximately 20 percent of its auto, homeowners, and workers compensation business in prior approval states. The average probability of failure for a firm in our sample is approximately 1.5 percent. Looking at our incentive to under-reserve (the difference between pre-managed violations IRIS violations and reported IRIS ratio violation) we observe that the incentive is positive for each measure. Finally, a majority of the firms have A.M. Best ratings of at least an A- or above.

[21] We use the definitions from Phillips, Cummins and Allen (1998).

[26] We plan on looking at a less restrictive test such as one examining those companies that were over-reserved during some significant part of the period. We also attempted to estimate a model of those firms who were under-reserved during the entire period, but there were not enough to generate results. We will also look at parsing the data to see if we can look at companies that were under-reserved (say) for fifty percent of the time.

5. Results

5.A Determinants of Over-Reserving

We undertake three tests of the likelihood of whether the firm over-reserves. First, we examine whether a firm over-reserves using the three year errors and second, we look at the likelihood of over-reserving for the five year errors. Finally, we analyze the proclivity for firms to be over-reserved for the entire sample period.

Our results for the first test are shown in Table 5 (for *Weiss* and *KFS* three year errors). We seek to determine whether over-reserving is a result of systematic effects. We estimate a logistic regression model with our dependant variable equal to one if the error is positive and zero otherwise for both the *W* and *KFS* errors. The independent variables are our variables of interest (Smooth, Tax, Solvency and Regulation) and other variables that control for size, product mix, organizational form, geographic and business concentration, size, growth, AM Best Ratings and fixed effects for year.

The tax shield is significantly related to whether a firm over-reserves for the *W* error but not for the *KFS* error. The smoothing incentive as measured by the three year average return on assets is insignificant for the *W* error, and significant, but of the wrong sign, for the *KFS* error. The *Smooth 2* incentive is of the correct sign and significant for only the KFS error. Thus, a loss last year implies a higher level of reserving this year so as to reduce the deviation from income expectations.

Looking at the incentive to under-reserve, the number of IRIS ratios the firm would have violated if there was no reserve error net of the number of Reported ratios the firm violates, we see that it is positively associated with the likelihood of over-reserving. This is contrary to the hypothesis described in the literature, but is consistent with the conjecture that firms determine reserves for reasons other than solvency.

In contrast, we see that the probability of firm failure coefficient for the *W* error model is negative, reflecting that firms in solvency trouble are less able to over-reserve and/or that stronger firms are less likely to under-reserve. For the *KFS* model, the probability of failure is not significant while the coefficient on IUR is positive. In addition, there is no significant difference in our measure of whether there was a change in the incentives brought about by the introduction of FAST and RBC after 1993.

For the effect of rate regulation variable, the percentage of premiums in regulated lines in prior approval states is positively associated with the likelihood of over-reserving for the *W* error, but not the *KFS* error. The positive relationship is contrary to Nelson's (2000) hypothesis that firms will under reserve in more heavily regulated lines, but consistent with our alternative conjecture that insurers will increase reserves to compensate for rate suppression.

Table 6 shows a similar set of regressions for the errors measured five years prior to resolution. The value of the tax shield is positive and significantly related to the likelihood of over-reserving for the *W* error, but negative for the *KFS* error. The smoothing incentive variables are also different for both errors. The incentive to under-reserve (IUR) is significant and positive in both models; however, it is once again of the wrong sign. The probability of failure is not significantly related to the likelihood of over-reserving. Taken together with the results from Table 5, this suggests that solvency is not as strongly related to the decision to over-reserve as reported in the literature. Finally, we see that the percent written in regulated lines in prior approval states is positively related to the likelihood of over-reserving for the *W* model. Again, this is evidence in favor of our alternative hypothesis.

After examining the propensity to over-reserve in any given year, we decided to investigate the companies that over-reserved for the entire period (1989-1999). Consistent over-reservers are likely to be different than those who over-reserve on a year to year basis. Table 7 shows the results from logistic regressions where the dependant variable is 1 if the insurer over-reserved for the entire sample period and is 0 other wise. For three of the four error measures (*W3*, *KFS3*, and *KFS5*) there are relatively large percentages of insurers who have over-reserved the entire period. Only for the *W5* error do we see a low percentage of over-reservers (4.2 percent).

For one of the measures (*W3*) we see a positive relationship between the likelihood of over-reserving and the value of the tax shield. For the two *KFS* models we see a negative relationship. The smoothing incentive as measured by the past average return on assets is consistently positive for these three models. The *Smooth 2* (a loss in the previous year) measure is negative and significantly related to over-reserving for the three models. Both smoothing incentive measures, however, do not seem to be testing the motivation to smooth income. Their relationship to consistent over-reserving is hard to justify and contrary to the expectations of the smoothing hypothesis, suggesting further work on the definition of smoothing is in order.

The probability of failure is negatively related to the likelihood of over-reserving in all cases, but is significant only for the case of the *W3* error. The incentive to under-reserve (IUR) is also positive (against expectations) for three out of the four error models. It is interesting to note that the interaction terms between the incentive to over-reserve and the pre-1993 regulatory environment is negative and significant for two of the models (*W3* and *KFS5).* This suggests that prior to 1993 the incentive to under-reserve to manipulate IRIS ratios is a factor that decreases a firm's willingness to consistently over-reserve.

In terms of efficiency, an interesting story develops. Five years prior to resolution firms with higher revenue efficiency are more likely to be over-reservers. However at three years prior to resolution, more efficient firms are less likely to be consistent over-reservers. This suggests that efficient firms may over-reserve for reasons unrelated to taxes, smoothing, or solvency protection and their decision to over-reserve is time dependant.[26] Perhaps, relative to their peers, more efficient firms are better able to predict their eventual resolution costs at 3 years.

5.B Magnitude of Over-reserving

Our next set of tests concern the size of the reserve error. The absolute value of the reserve error is regressed against a set of independent variables to assess how the magnitude of the loss relates to the received hypotheses. Others researchers have used a similar procedure in which the absolute value of the error is regressed against a model similar to the following (see e.g. Browne et al. (2004) or Beaver et al. (2003)):

$$ABS(Error) = \alpha + Pos\_Error * (\mathbf{B}_1\mathbf{X}) + Neg\_Error * (\mathbf{B}_2\mathbf{X}) + e \qquad (4)$$

where *ABS(Error)* represents the absolute value of the reserve error, *Pos_Error* is an indicator for whether the error is positive (over-reserve), *Neg_Error* is an indicator for whether the error is a negative error (under-reserve), and the $\mathbf{B}_i$ represent vectors of coefficients on a common set of explanatory variables, **X**. A model of this form, however, is expected to be a misspecification of the positive/negative error generating process to the degree that positive errors are generated by a different function than negative errors. Accordingly, by estimating the regression (4) we are constraining the result. We propose an alternative estimation:

$$ABS(Error) = \alpha_1 + \boldsymbol{\beta}_1\mathbf{X} + \xi_1 \text{ if } Error < 0$$
$$ABS(Error) = \alpha_2 + \boldsymbol{\beta}_2\mathbf{X} + \xi_2 \text{ if } Error > 0 \quad (5)$$

The preference of equation (5) is verified using a Wald Test. The null hypothesis that the restricted model (4) dominates the unconstrained model (5) is rejected at the 0.01 level in all four cases (*W3, W5, KFS3,* and *KFS5*).

The estimates for the various models of over- and under-reserving are shown in Table 8 (Panels A-D). The regressions are interesting in the relative absence of significant relationships to explain the magnitude of the error. The explanatory power of the models is uniformly low. While the tax shield variable is positively related to the magnitude of a positive error in Panel A, *Smooth 2* (the presence of a loss last year) is negatively related to the size of the error. Further, for the first time the incentive to under-reserve has the correct sign. However, for the most part, none of the explanatory variables do a consistent job in explaining the size of the error. The R^2 across the different model specifications is approximately 0.02, implying that a firm's reserve error is likely to be the result of error rather than manipulation for what ever reason.

5.C Source of Reserve Error

Previous studies examining the discretionary behavior of loss reserve estimation focus on *a priori* beliefs of a firm's discretionary incentives (Penalva, 1998; and Petroni, Ryan, and Whalen, 2000). Loss reserve errors are categorized as non-discretionary events if they "unbiasedly" reveal new information about claims, such as the type of business an insurer writes. Loss reserve errors are classified as discretionary behavior if prior literature discovered an incentive to be significantly related to loss reserve errors, e.g. tax status or financially weak insurers. We believe this type of examination is limited since the discretionary component is pre-determined. As an alternative, we examine whether the deviation from the expected proportional use of a subjective component of reserves is correlated with firm incentives.[27]

As we mention above, loss reserves are comprised of two components, the case reserve and the IBNR reserve. The case reserve is a claim adjuster's estimate of the

[27] Another test of discretionary behavior in loss reserve estimation (and perhaps a more appropriate one) is a direct examination of whether a particular incentive to over- or under-reserve is contemporaneously correlated with the loss reserve error, i.e., a test of endogeneity.

settlement amount based on the facts of the case at the time a claim is initially reported. During the claims adjustment process, an adjuster may revise the case reserve and make partial payments on the claim. In sum, the case reserve is the amount that will be required for the future payment of claims that have been reported to the insurer.

The IBNR reserve, on the other hand, is an estimate of claims that have been incurred but have yet to be reported to the firm. Over the coverage period, the IBNR reserve steadily decreases as the estimated level of still unreported claims falls. Considerable difficulties and greater subjectivity are encountered in estimating the likelihood, timing, and magnitude of claims that have yet to be reported (Aiuppa and Trieschmann (1987)). As such, the IBNR reserve might be the source of the subjective over or under-reserving taking place in insurers.

We utilize the greater subjectivity inherent in estimating IBNR reserves to conduct a test of discretionary behavior which does not rest upon *a priori* beliefs of how discretion should manifest itself in loss reserve revisions. Because IBNR depends upon a number of different variables, we attempt to first predict what a firm would choose for its composition of IBNR reserves to total reserves so that we may, in the second stage, examine the difference between expectation and what actually occurs. In accordance with that objective, we first estimate the following regression:

$$\frac{IBNR\ Reserves}{Total\ Reserves} = \eta + \boldsymbol{\theta}\mathbf{Z} + \xi \,, \qquad (6)$$

where η is the intercept, $\boldsymbol{\theta}$ is a vector of coefficients, $\mathbf{Z}$ is a vector of explanatory variables and ξ is an error term. For our explanatory variables we use firm size, organizational form, business mix,[28] the line of business Herfindahl index, the geographic Herfindahl index, AM Best Ratings, and year fixed effects.

Second, an estimate of the deviation from the expected ratio of IBNR to total reserves, the absolute value of the error term from regression (6), is obtained.. The difference between the actual ratio and the expected ratio should be white noise if managers do not exercise managerial discretion. However, if setting the proportional amount of IBNR reserves is done in an intentional, systematic way the absolute deviation from expectation will be correlated with the firm's incentives to under- or over-utilize IBNR. To verify

[28] Percentage of business in commercial short tail lines, personal long tail lines, and commercial long-tail lines.

whether a firm's incentives are correlated with the absolute deviation from expectation we estimate the following regression models:

$$\begin{aligned} \left|IBNR\ Dev\right|^{-} &= \alpha + \boldsymbol{\beta}\mathbf{X} + e^{-} \ \ if \ \ IBNR\ Dev < 0 \\ \left|IBNR\ Dev\right|^{+} &= \alpha + \boldsymbol{\varphi}\mathbf{X} + e^{+} \ \ if \ \ IBNR\ Dev > 0 \end{aligned} \tag{7}$$

where |IBNR Dev| is the absolute value of the error term from regression (6). The plus and minus superscripts refer to the positive and negative errors respectively. The explanatory variables in the above regression are the two smoothing incentive variables, the value of the tax shield, revenue efficiency, the probability of failure, the percent of total premiums earned in relatively regulated lines in prior approval states, the under-reserving incentive (IUR), the pre-1993 under-reserving incentive, an indicator for a public stock company, and growth in net premiums written.

Figure 5 graphically describes our methodology. The left side of the figure displays firms that use less than the predicted proportion of IBNR to total reserves, i.e., negative deviations from expectation. The right side of the figure shows positive deviations from expectation.

Suppose a firm has a relatively high incentive to smooth income (characterized by a three-year average return on assets, *Smooth*). If IBNR is the source of a firm's income smoothing behavior, then *Smooth* should be positively correlated with the absolute deviation from the expected IBNR to total reserve ratio given that the firm's ratio is lower than expected. This is represented by a greater absolute deviation from expectation, which is a leftward movement in the left side of Figure 5. On the other hand, given the firm's absolute deviation is greater than expected the smoothing hypothesis predicts a less IBNR usage, represented by a leftward movement in the right side of Figure 5. In general, as *Smooth* increases, we expect the firm to use its subjective IBNR to under-reserve relative to expectation.

The empirical results are located in Table 9 Panels A (3-year) and B (5-year). Each panel contains four regressions: two for the *W* error and two for the KFS error. The first regression examines the effect of certain explanatory variables on the absolute size of the ratio of IBNR to total reserves given that this ratio is below the average. The second regression looks at the case where the insurer's ratio of expected IBNR to total reserves is greater than the expectation.

Looking at the regression results as a whole, we note the explanatory power of the model is quite low. Thus, while certain variables may be significant, we only explain a relatively low percentage of the over and under use of IBNR as a ratio to total reserves.[29]

The tax shield has no significant effect on the five-year error models , but there is there is a tax shield influence on the three year error. Thus there appears to be a time horizon issue in a firm's IBNR usage.. Conditional on being under the expected ratio of IBNR to total reserves for the pair of five year errors shown in Panel B of Table 9, increases in the tax shield (increase) reduce the deviation ~~for both errors~~.[30] In contrast, given the firm is above expectations, an increase in the tax shield increases the ratio of IBNR to total reserves.

According to the smoothing hypotheses, if profits are unexpectedly higher (lower) in the present period, then the firm will over (under) reserve. The smoothing incentive variables are significant in most of the models. The three year moving average definition of smoothing is positive and significant for those firms which are using less than the expected amount of IBNR to total reserves. Thus, conditional on being under the expected level of IBNR to reserves, as the three year moving average of net income increases, the insurer under-estimates its IBNR reserve component and thereby boosts its reported income. This is true for both the *W* and *KFS* error. There is no evidence that the insurer is over using IBNR relative to total reserves.

For efficiency if the firm is under using IBNR, an increase in efficiency increases the deviation from the expectation. In contrast, if insurers are over the expected ratio, then an increase in efficiency reduces the deviation from the expectation. This is true for both error calculations. An increase in the percentage of premiums written in regulated business shows a reduction in the deviation from expectations.

The absolute deviation from the expected proportion of IBNR to total reserves is larger for firms with a higher probability of failure regardless of whether the firm is above of

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[29] The underlying regressions for equation (6) above have R^2s of 0.41 for the three year error and 0.48 for the five year error. So we can think of the R^2s of the models shown in Table 9 as "incremental R^2s" in the sense that this is the additional explanatory power obtained from running the regressions in Table 9.

[30] To provide some economic content to the effect of the tax shield, we calculated the elasticity of the effect of the tax shield on the dependant variable. For firms that were under utilizing their IBNR relative to total reserves the tax shield elasticity was -0.004 (for both *W* and *KFS* models). That is, a 10 percent increase in the tax shield yields a 0.04 percent decrease in the deviation from the expectation. For the regression for firms above the expectation the elasticity was 0 (for both *W* and *KFS* models). These are likely to be economically insignificant effects relative to other potential influences.

below the predicted ratio. This is an interesting result. It indicates firms with a relatively high probability of insolvency are more likely to over use their IBNR, given they have a higher IBNR usage ratio than expected. In contrast, firms with a higher likelihood of failure under use their IBNR given that they have a lower IBNR usage ratio than expected. The under utilization of IBNR is consistent with Harrington and Danzon's (1994) moral hazard hypothesis that firms with weakened franchise values (high probability of failure) will under-estimate their IBNR reserve to conceal inadequate prices from regulators. However, the over utilization of IBNR by firms with a relatively high probability of failure suggests that some weak firms demonstrate an increased conservativeness in reserving for unreported losses to increase firm safety.

The incentive to over-reserve is significant for all firms but the sign of the effect depends upon whether the firm is below expectations (negative) or above expectations (positive). In addition, there are differing effects for the 3-year and 5-year error definitions. The incentive to under reserve is insignificant for the 3-year error, but significant for the 5-year error. For the 5-year error the incentive to under-reserve negatively impacts the degree of IBNR under-reserving if the insurer is under the expectation and positively impacts the degree of IBNR over-reserving if the insurer is over expectations. We see a second effect for the incentive to over-reserve for years prior to 1993 and these effects, when significant, are the opposite sign of the coefficient on the incentive to reserve, implying that the incentives had a different affect prior to 1993. The *IUR* variable prior to 1993 increases IBNR under-reserving if the insurer is under the expectation and decreases the positive deviation if the insurer is over expectations.

In sum, Table 9 demonstrates that by controlling for certain firm effects, we can see whether the IBNR is the source of changes in reserves. Many of our hypothesized variables do have an affect on the IBNR to total reserves ratio and that the effects are generally different if the firm is under or over using IBNR relative to total reserves. However, the increment in explanatory power of these discretionary variables is often quite small. Thus, while managerial discretion can influence the ratio of IBNR to total reserves, it appears that it is a relatively small effect.

6. Conclusions

We have undertaken a number of tests regarding hypotheses generated in the literature, as well as some alternates regarding an insurer's incentive to over or under-reserve. First, the incentive to over-reserve for insurers using different measures of reserving error is investigated. Second, we examined the propensity to be over-reserved for a significant period of time. Third, the determinants of the magnitude of loss reserves are examined, and finally we investigate the extent to which the IBNR reserve is the source of reserve error.

The incentive to under-reserve (the difference between reserve error free IRIS ratio violations purged and the reported IRIS ratio violations) was often the wrong sign suggesting that the incentive to under-reserve to avoid regulatory scrutiny is not related to whether the firm under-reserves. While taxes seem to be a motivation for over-reserving, they are apparently related to the use of IBNR reserves only for the three year error. Management quality as measured by our revenue efficiency measure has some power to explain why firms do not consistently over-reserve, for example, and why they might increase or decrease reliance on IBNR reserves.

In this initial foray we also do not find overwhelming evidence that "weaker" firms are more likely to mis-reserve to a greater extent than other firms, which contrasts previous findings. We use a more sophisticated measure of firm weakness, the firm's default likelihood, which may be too strong a definition. However, the alternative measure, the failure of a subset of IRIS ratios, does not necessarily measure true firm weakness.

We also note two problems with the variables used in the literature. The first is in reference to the error term definition. We do not make a case for one over the other here, but note that the results are often not robust between the two error definitions. Secondly, we note that there is a potential problem with the way the smoothing variables are defined. Smoothing should be in reference to some target return (ROA^*) and if the insurer is under (over) the target, it should over (under) reserve if smoothing matters to the insurer.

In general the explanatory power of our models is relatively low. This suggests that there is a good deal of uncertainty in setting reserves. Further, research needs to determine the appropriate error measure as well as whether incentives to reserve result in truly material reserve changes. In the future, we plan to use other frontier measures of managerial efficiency. In addition, the role of many of the control variables needs to be explored in more detail as some (like whether the firm is listed on a public exchange or its AM Best rating) are also likely to be relevant to the firm's behavior.

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Table 1. Descriptive Statistics for Various Error Definitions

Panel A. Summary Statistics for Various Measures of Reserving Error as a Percentage of Firm Assets

1. Overall	Obs	Mean	Std.	Min	Max
Weiss Error 3 Year	9544	0.147	0.567	-3.073	30.660
KFS Error 3 Year	9544	0.001	0.443	-30.352	4.226
Weiss Error 5 Year	6497	0.165	3.765	-2.728	301.025
KFS Error 5 year	6497	0.040	3.817	-33.788	301.007
2. Error Ratios with +/- 2.0 and All Fast Ratios are Calculated					
Weiss Error 3 Year	9523	0.133	0.155	-1.542	1.879
KFS Error 3 Year	9523	0.010	0.102	-1.543	1.483
Weiss Error 5 Year	6483	0.106	0.162	-1.949	1.974
KFS Error 5 year	6483	0.013	0.133	-2.781	1.656
3. Positive Error Statistics					
Weiss Error 3 Year	8722	0.1521	0.142	0.000	1.879
KFS Error 3 Year	6069	0.0535	0.064	0.000	1.483
Weiss Error 5 Year	5640	0.1354	0.139	0.000	1.974
KFS Error 5 year	4153	0.0690	0.078	0.000	1.656
4. Negative Error Statistics					
Weiss Error 3 Year	803	-0.0820	0.167	-1.961	0.000
KFS Error 3 Year	3447	-0.0673	0.117	-1.583	0.000
Weiss Error 5 Year	843	-0.0925	0.164	-1.949	0.000
KFS Error 5 year	2328	-0.0839	0.134	-1.989	0.000

Note: Each error is expressed as a percentage of total assets.

Panel B. Correlations Among Reserving Error Terms

	Weiss Error 3 Year	KFS Error 3 year	Weiss Error 5 Year	KFS Error 5 year
Weiss Error 3 Year	1.000			
KFS Error 3 Year	0.373	1.000		
Weiss Error 5 Year	0.027	0.013	1.000	
KFS Error 5 year	0.004	0.025	0.991	1.000

N =6320

Note: Firms were included if there were FAST Ratios, efficiency scores, and had error ratios within the +/-2 range. Weiss error is the difference between reserves and claims paid in a given year while the KFS error is the difference between the loss reserve in a given year in the past and the loss reserve in the current period.

Table 2.

Insurance Regulatory Information System (IRIS) Ratios - Definitions, Regulatory Bounds, and Relation to Loss Reserves Error

	Ratio	Lower Bound	Upper Bound	Impact of Loss Reserves Error on Ratio
1	Net Premiums Written / Policyholders' Surplus	None	3.00	Under-reserving improves this ratio by increasing surplus
2	Change in Net Premiums Written	0.33	0.33	Loss reserves do not affect this ratio
3	Surplus aid / Policyholders' Surplus	None	0.25 (1988-1992) 0.15 (1993-1999)	Under-reserving improves this ratio by increasing surplus
4	2-Year Operating Ratio	None	1.00	Under-reserving decreases current losses, which improves the 2-year overall operating ratio
5	Investment Yield	0.050 (1988-1992) 0.045 (1993-1999)	None 0.10 (1993-1999)	Loss reserves do not affect this ratio
6	% Change in Policyholders' Surplus	0.10	0.50	Under-reserving increases policyholders' surplus, but the overall impact on this ratio indeterminate
7	Liabilities / Liquid Assets	None	1.05	Under-reserving improves this ratio by reducing liabilities
8	Agents' Balances / Policyholders' Surplus	None	0.40	Under-reserving improves this ratio by increasing surplus
9	1-year Reserve Development / Policyholders' Surplus_{t-1}	None	0.25 (1988–1992) 0.20 (1993-1999)	In general, under-reserving improves this ratio
10	2-year Reserve Development / Policyholders' Surplus_{t-2}	None	0.25 (1988–1992) 0.20 (1993-1999)	In general, under-reserving improves this ratio
11	Current Estimated Reserve Deficiency / Policyholders' Surplus	None	0.25	In general, under-reserving increases (worsens) this ratio
12	Gross Premiums Written / Policyholders' Surplus (ratio added in 1993)	None	9.00	Under-reserving improves this ratio by increasing surplus

Note: IRIS ratios are obtained from Using the NAIC Insurance Regulatory Information System: Property and Liability Edition (National Association of Insurance Commissioners, 1988–1999). Unless otherwise noted, reported bounds are in effect throughout the 1988–1999 sample period.

Policyholders' Surplus is analogous to the stockholders' equity accounts (retained earnings, common stock, preferred stock, and additional paid-in capital) of a company following generally accepted accounting principles.

Net Premiums are gross premiums reduced by reinsurance ceded to affiliates and non-affiliates.

Change in Net Premiums Written is the increase or decrease in net premiums written, divided by net premiums written in the prior year.

Surplus Aid is the ratio of commissions on ceded reinsurance to premiums for ceded reinsurance multiplied by the unearned premiums on reinsurance ceded to nonaffiliates. [(Commissions on ceded reinsurance/Premiums for ceded reinsurance) X Unearned premiums on reinsurance ceded to nonaffiliates]

2-year Operating Ratio is the loss ratio, plus the expense ratio, minus the net investment ratio, all measured during a 2-year period.

Loss ratio is the sum of losses, loss expenses incurred, and policyholder dividends over premiums earned.

Expense Ratio is other underwriting expenses and deductions over premiums written.

Net Investment Ratio is net investment income over premiums earned.

Investment Yield is two times net investment income divided by the average amount of cash and invested assets during the year. Net investment income is the sum of interest, dividends and real estate income (excludes capital gains on sales of investments).

% Change in Surplus is the increase or decrease in policyholders' surplus as a percentage of policyholders' surplus at the end of the prior year.

Liabilities are obligations including estimated losses, such as incurred but not reported reserves.

Liquid Assets are cash and other investments (such as bonds), reported at their annual statement (book) value.

Agents' Balances are agents' balances in the course of collection.

One-Year Reserve Development is the estimated incurred loss for all years except the current year minus the incurred loss for all years as reported at the end of the prior year.

Two-Year Reserve Development is the estimated incurred loss for all years except the current and prior year, minus the incurred loss for all years as reported at the end of the year before the prior year.

Current Estimated Reserve Deficiency is the difference between the estimated reserves for the company and the actual reserves reported by the company.

Gross Premiums is the sum of gross premiums written from direct business and reinsurance from affiliates and nonaffiliates.

Table 3. Comparison of the Sum of the Number of Reported IRIS Violations versus the Pre-Managed Number of Ratios with Violations

	Mean	Quartile 1	Median	Quartile 3	Std. Dev.
Panel A. Reported IRIS Ratio Violations					
Reported Sum of IRIS Ratio with Values Outside of Acceptable Boundaries	1.123	0	1	2	1.298
Panel B. Pre-managed IRIS Ratios Violations					
Sum of Estimated Number of Pre-Managed IRIS Ratios with Values Outside Acceptable Boundaries Using Weiss 3 Year Error	2.147	1	2	3	1.450
Sum of Estimated Number of Pre-Managed IRIS Ratios with Values Outside Acceptable Boundaries Using KFS 3 Year Error	1.490	0	1	2	1.391
Sum of Estimated Number of Pre-Managed IRIS Ratios with Values Outside Acceptable Boundaries Using Weiss 5 Year Error	2.101	0	2	3	1.442
Sum of Estimated Number of Pre-Managed IRIS Ratios with Values Outside Acceptable Boundaries Using KFS 5 Year Error	1.556	0	1	2	1.396

Pre-managed IRIS ratios are IRIS ratios that are purged of the effect of loss reserve estimation error. See Table 3 for how loss reserve error impacts the individual IRIS ratios.

Table 4. Summary Statistics for Sample.

Variable	Obs	Mean	Std. Dev.	Min	Max
Firm Characteristics					
Indicator for Mutual	10875	0.193	0.394	0.000	1.000
Indicator for Stock Company	10875	0.671	0.470	0.000	1.000
Indicator for RRG	10875	0.002	0.042	0.000	1.000
Indicator for Reciprocal	10875	0.020	0.139	0.000	1.000
Indicator for Direct Writer	10760	0.161	0.368	0.000	1.000
Indicator for Member of a Group	10875	0.756	0.429	0.000	1.000
Indicator for Public Stock Company	10875	0.135	0.342	0.000	1.000
Concentration					
Percent losses incurred in Commercial Short Tail	10829	0.254	1.015	0.000	86.273
Percent losses incurred in Commercial Long Tail	10829	0.354	0.800	0.000	60.000
Percent losses incurred in Personal Long Tail	10829	0.315	0.429	0.000	33.909
Percent losses incurred in Personal Short Tail	10829	0.098	0.138	0.000	4.083
Product Line Herfindahl	10875	0.355	0.247	0.000	1.000
Geographic Herfindahl	10250	0.512	0.376	0.030	1.000
Efficiency, Size and Growth					
Revenue Efficiency	10875	0.176	0.211	0.000	1.000
Total Assets	10875	$558,000,000	$2,480,000,000	$ 409,494	$80,100,000,000
Net Premium Written Growth Rate * 100	10832	24.458	135.357	-164.127	2992.385
Tax and Income Characteristics					
Value of the Tax Shield for 3 Year Error	10442	89.581	3134.606	0.000	215277.800
Value of the Tax Shield for 5 Year Error	8448	48.249	1980.372	0.000	172792.700
Smooth -- MA 3 Year (Net Income/Assets)	9469	0.026	0.084	-1.494	5.599
Smooth 2--Indicator for Net Income (t-1) < 0	10875	0.189	0.392	0.000	1.000
Regulation					
Prob of Failure (t-1)	10875	0.015	0.023	0.000	0.970
Incentive to Under Reserve for W3 Error	10368	1.117	1.461	-5.000	6.000
Incentive to Under Reserve for KFS3 Error	10368	0.387	0.907	-5.000	6.000
Incentive to Under Reserve for W5 Error	7085	1.173	1.447	-5.000	6.000
Incentive to Under Reserve for KFS 5 Error	7085	0.552	1.027	-5.000	6.000
Pct Prems Earned in Regulated Lines in Prior Appro	10871	0.199	0.279	0.000	1.000
Best Rating: C++ or C+	10760	0.005	0.070	0.000	1.000
Best Rating: B or B-	10760	0.041	0.198	0.000	1.000
Best Rating: B+ or B++	10760	0.119	0.323	0.000	1.000
Best Rating: A or A-	10760	0.456	0.498	0.000	1.000
Best Rating: A+ or A++	10760	0.277	0.448	0.000	1.000

Companies are in the sample if they have an estimate of Revenue Efficiency, a Probability of Failure, and Positive Loss Reserves.

In addition, this table represents a sample that different slightly from our empirical tests. Each test ahs a different sample size. This particular set of descriptive statistics is representative of the sample we use in each test.

Table 5. Logistic Regression for Postive Errors with Errors Determined based Upon 3 Year Terms for *Weiss* and *KFS* Errors

	Dependent Variable is 1 if Error > 0, 0 otherwise							
	Model 1 (W Error > 0)				**Model 2 (KFS Error > 0)**			
	Coeff	std err	t	p	Coeff	std err	t	p
Intercept	3.127	5.222	0.600	0.549	-2.508	2.339	-1.070	0.284
Indicator for Mutual	**0.487**	0.141	3.460	0.001	**0.574**	0.079	7.290	0.000
Indicator for Reciprocal	**1.233**	0.536	2.300	0.021	**0.831**	0.205	4.050	0.000
Indicator for RRG	-				0.999	1.091	0.920	0.360
Indicator for Lloyds	0.225	0.494	0.460	0.648	-0.346	0.288	-1.200	0.230
Indicator for Direct Writer	0.225	0.145	1.550	0.121	**0.555**	0.076	7.280	0.000
Indicator for Member of a Group	**0.322**	0.114	2.830	0.005	-0.077	0.070	-1.090	0.276
Indicator for Public Stock Company	0.253	0.175	1.440	0.149	**0.396**	0.073	5.400	0.000
Product Mix								
Percent losses incurred in Commercial Short Tail	0.349	0.341	1.020	0.305	**0.102**	0.058	1.740	0.081
Percent losses incurred in Personal Long Tail	0.370	0.402	0.920	0.357	**0.602**	0.088	6.810	0.000
Percent losses incurred in Commercial Long Tail	0.364	0.332	1.100	0.273	**-0.515**	0.067	-7.700	0.000
Product Line Herfindahl	0.000	0.001	0.090	0.931	0.000	0.001	-0.190	0.850
Geographic Herfindahl	**0.414**	0.157	2.650	0.008	**0.160**	0.083	1.940	0.053
Efficiency								
Revenue Efficiency	-0.344	0.249	-1.380	0.167	-0.104	0.161	-0.640	0.519
Size								
Log of Total Assets	-0.542	0.577	-0.940	0.347	**0.596**	0.239	2.500	0.013
Log of Total Assets2	0.021	0.016	1.330	0.183	**-0.017**	0.006	-2.720	0.006
Growth								
Net Premium Written Growth Rate * 100	1.1E-04	1.6E-04	0.700	0.481	-2.03E-06	3.3E-06	-0.610	0.540
Income & Tax								
Value of Tax Shield 3 Year (Weiss or KFS)	**0.199**	0.023	8.480	0.000	0.000	0.000	-1.270	0.203
Smooth 2--Indicator for Net Income (t-1) < 0	-0.144	0.111	-1.300	0.193	**-0.332**	0.065	-5.070	0.000
Smooth -- MA 3 Year (Net Income/Assets)	-0.596	1.139	-0.520	0.600	**3.251**	0.675	4.820	0.000
Solvency and Regulation								
Prob of Failure (t-1)	**-6.684**	3.088	-2.160	0.030	0.888	2.315	0.380	0.701
Incentive to Under Reserve	**0.758**	0.104	7.260	0.000	**0.369**	0.057	6.460	0.000
Incentive to Under Reserve Prior to 1993	-0.087	0.115	-0.750	0.452	-0.077	0.066	-1.150	0.248
Pct Prems Earned in Regulated Lines in Prior Approva	**0.504**	0.181	2.790	0.005	0.017	0.096	0.180	0.856
Best Rating: C++ or C+	**-1.047**	0.389	-2.690	0.007	-0.280	0.330	-0.850	0.395
Best Rating: B or B-	**-0.993**	0.195	-5.080	0.000	-0.229	0.156	-1.470	0.142
Best Rating: B+ or B++	-0.097	0.171	-0.570	0.570	0.007	0.121	0.060	0.954
Best Rating: A or A-	**0.624**	0.167	3.740	0.000	**0.276**	0.113	2.430	0.015
Best Rating: A+ or A++	**0.765**	0.199	3.840	0.000	**0.484**	0.123	3.940	0.000

Note: Year Indicators ommitted and bolded coefficients denote significance at at least the 0.10 level.

	Model 1	Model 2
Log Likelihood	-1735	-5024
N	8402	8398
Pseudo R^2	0.226	0.079

Table 6. Logistic Regression for Postive Errors with Errors Determined based Upon 5 Year Terms for Weiss and KFS Errors

	Dependent Variable is 1 if Error > 0, 0 otherwise							
	Model 1 (W Error >0)				**Model 2 (KFS Error > 0)**			
	Coeff	std err	t	p	Coeff	std err	t	p
Intercept	8.469	5.577	1.520	0.129	**-14.624**	2.961	-4.940	0.000
Indicator for Mutual	**0.238**	0.136	1.750	0.081	**0.644**	0.094	6.820	0.000
Indicator for Reciprocal	**1.319**	0.538	2.450	0.014	**1.184**	0.291	4.070	0.000
Indicator for RRG	0.090	1.171	0.080	0.939	0.360	1.130	0.320	0.750
Indicator for Lloyds	0.211	0.664	0.320	0.750	-0.209	0.391	-0.530	0.593
Indicator for Direct Writer	**0.368**	0.147	2.510	0.012	**0.471**	0.094	5.010	0.000
Indicator for Member of a Group	**0.205**	0.115	1.770	0.076	-0.171	0.089	-1.920	0.054
Indicator for Public Stock Company	-0.110	0.168	-0.650	0.513	**0.604**	0.096	6.270	0.000
Product Mix								
Percent losses incurred in Commercial Short Tail	0.155	0.151	1.030	0.304	0.119	0.112	1.060	0.287
Percent losses incurred in Personal Long Tail	-0.126	0.227	-0.550	0.581	**1.018**	0.166	6.120	0.000
Percent losses incurred in Commercial Long Tail	-0.259	0.172	-1.510	0.132	**-0.335**	0.121	-2.770	0.006
Product Line Herfindahl	0.000	0.001	0.060	0.954	**0.684**	0.149	4.570	0.000
Geographic Herfindahl	**0.543**	0.153	3.560	0.000	**0.373**	0.102	3.640	0.000
Efficiency								
Revenue Efficiency	-0.220	0.300	-0.730	0.465	-0.202	0.230	-0.880	0.379
Size								
Log of Total Assets	**-1.163**	0.605	-1.920	0.055	**1.410**	0.307	4.590	0.000
Log of Total Assets2	**0.037**	0.016	2.250	0.025	**-0.037**	0.008	-4.650	0.000
Growth								
Net Premium Written Growth Rate * 100	0.000	0.000	0.490	0.626	0.000	0.000	-0.790	0.432
Income & Tax								
Value of Tax Shield 5 Year (Weiss or KFS)	**0.244**	0.029	8.520	0.000	**-0.003**	0.001	-2.150	0.031
Smooth -- MA 3 Year (Net Income/Assets)	**-3.513**	1.242	-2.830	0.005	**3.184**	0.890	3.580	0.000
Smooth 2--Indicator for Net Income (t-1) < 0	0.135	0.119	1.130	0.256	-0.064	0.084	-0.750	0.451
Solvency and Regulation								
Prob of Failure (t-1)	1.559	4.141	0.380	0.707	4.546	3.338	1.360	0.173
Pct Prems Earned in Regulated Lines in Prior Approv	**0.441**	0.187	2.360	0.018	0.061	0.126	0.490	0.627
Incentive to Under Reserve	**0.345**	0.047	7.280	0.000	**0.196**	0.054	3.660	0.000
Incentive to Under Reserve Prior to 1993	**0.340**	0.053	6.380	0.000	0.039	0.066	0.590	0.554
Best Rating: C++ or C+	**-1.315**	0.444	-2.960	0.003	**-1.300**	0.477	-2.730	0.006
Best Rating: B or B-	**-0.698**	0.225	-3.100	0.002	-0.249	0.195	-1.280	0.202
Best Rating: B+ or B++	-0.025	0.182	-0.140	0.891	0.165	0.156	1.060	0.288
Best Rating: A or A-	**0.979**	0.176	5.570	0.000	**0.448**	0.146	3.070	0.002
Best Rating: A+ or A++	**1.543**	0.209	7.380	0.000	**0.715**	0.158	4.530	0.000

	Model 1	Model 2
Log-Likelihood	-1641	-3300
N	5628	5626
Pseudo R^2	0.1941	0.097

Table 7. Logistic Regression of Whether the Firm is Always Over Reserving During the Panel Period

	Weiss Error 3 year	Weiss Error 5 Year	KFS Error 3 year	KFS Error 5 Year
Intercept	9.503	-30.694	-15.025	-21.812
	(3.355) ***	(11.032) ***	(2.258) ***	(3.854) ***
Indicator for Mutual	0.333	0.263	0.746	0.272
	(0.081) ***	(0.202)	(0.072) ***	(0.102) ***
Indicator for RRG	2.724	--	-0.271	0.799
	(1.125) **		(0.769)	(0.985)
Indicator for Lloyds	0.208	0.315	--	--
	(0.312)	(0.643)		
Indicator for Reciprocal	1.973	-1.669	0.928	0.970
	(0.330) ***	(1.027)	(0.196) ***	(0.212) ***
Indicator for Direct Writer	0.117	0.238	0.795	0.379
	(0.082)	(0.196)	(0.076) ***	(0.093) ***
Indicator for Member of a Group	0.354	0.286	-0.199	-0.243
	(0.073) ***	(0.173) *	(0.070) ***	(0.097) **
Indicator for Public Stock Company	0.319	-1.907	0.686	0.600
	(0.090) ***	(0.516) ***	(0.072) ***	(0.093) ***
Product Mix				
Percent losses incurred in Commercial Short Tail	-0.237	-0.896	0.225	0.041
	(0.062) ***	(0.507) *	(0.108) **	(0.101)
Percent losses incurred in Commercial Long Tail	0.580	-1.259	-0.406	0.003
	(0.075) ***	(0.484) ***	(0.113) ***	(0.124)
Percent losses incurred in Personal Long Tail	-0.403	-2.134	1.141	0.721
	(0.095) ***	(0.609) ***	(0.152) ***	(0.166)
Product Line Herfindahl	0.000	0.000	0.906	0.000
	(0.000)	(0.001)	(0.116) ***	(0.001)
Geographic Herfindahl	0.531	-0.240	0.021	0.379
	(0.093) ***	(0.232)	(0.082)	(0.109) ***
Efficiency				
Revenue Efficiency	-0.178	0.751	-0.661	0.606
	(0.171)	(0.374) **	(0.165) ***	(0.250) **
Size				
Log of Total Assets	-1.531	3.885	1.567	2.051
	(0.367) ***	(1.241) ***	(0.238) ***	(0.400) ***
Log of Total Assets2	0.052	-0.124	-0.044	-0.055
	(0.010) ***	(0.035) ***	(0.006) ***	(0.010) ***
Growth				
Net Premium Written Growth Rate * 100	8.67E-06	-3.58E-04	-1.88E-05	-1.91E-05
	(1.36E-05)	(4.12E-04)	(2.17E-05)	(4.95E-05)
Tax and Income				
Value of Tax Shield 5 year (KFS)	0.002	0.000	-0.004	-0.037
	(0.001) **	(0.000)	(0.002) *	(0.012) ***
Smooth 2--Indicator for Net Income (t-1) < 0	-0.179	-0.079	-0.202	-0.283
	(0.072) **	(0.183)	(0.066) ***	(0.109) ***
Smooth -- MA 3 Year (Net Income/Assets)	1.038	-0.928	7.384	10.739
	(0.700)	(1.629)	(0.718) ***	(1.066) ***
Solvency				
Prob of Failure (t-1)	-4.592	-4.738	-0.721	-5.461
	(2.565) *	(6.397)	(2.304)	(4.737)
Best Rating: C++ or C+	-0.601	-0.398	--	--
	(0.391)	(0.659)		
Best Rating: B or B-	-0.484	-1.238	-0.209	-0.282
	(0.163) ***	(0.393) ***	(0.153)	(0.315)
Best Rating: B+ or B++	0.276	-0.666	0.218	0.112
	(0.124) **	(0.250) ***	(0.122) *	(0.224)
Best Rating: A or A-	0.908	-0.844	0.417	0.770
	(0.116) ***	(0.229) ***	(0.116) ***	(0.204) ***
Best Rating: A+ or A++	0.964	-0.927	0.765	1.268
	(0.128) ***	(0.279) ***	(0.126) ***	(0.212) ***
Incentive to Under Reserve	0.401	-0.273	0.292	0.514
	(0.047) ***	(0.075) ***	(0.057) ***	(0.059) ***
Incentive to Under Reserve Prior to 1993	-0.099	0.238	-0.090	-0.251
	(0.053) *	(0.196)	(0.065)	(0.070) ***
Pct Prems Earned in Regulated Lines in Prior Approv	0.826	-0.923	0.023	-0.110
	(0.105) ***	(0.313) ***	(0.096)	(0.130)
N	8410	5622	8410	5568
Psuedo-R^2	0.202	0.150	0.111	0.126
Percent of Firms with Consistent Positive Errors over Time Period	69%	4.2%	58%	26%
Year Effects Ommitted				

Table 8. Panel A. Weiss Reserving Error for Three Years. Dependent Variable is the Absolute Value of the Loss Reserve Error as a Percentage of Total Assets. Estimates from Prais- Whinsten Regression.

	Magnitude of Under Reserving				**Magnitude of Over Reserving**			
	Coef	Std. Error	t	prob > t	Coef	Std. Error	t	prob > t
Intercept	**3.140**	1.533	2.050	0.041	**-2.321**	1.088	-2.130	0.033
Indicator for Mutual	**0.057**	0.033	1.710	0.088	-0.019	0.023	-0.800	0.421
Indicator for Reciprocal	-0.115	0.197	-0.580	0.560	0.001	0.060	0.020	0.985
Indicator for RRG					0.007	0.234	0.030	0.976
Indicator for Lloyds	0.002	0.092	0.020	0.983	0.014	0.119	0.120	0.906
Indicator for Direct Writer	0.001	0.039	0.030	0.979	**0.013**	0.033	0.410	0.680
Indicator for Member of a Group	-0.007	0.031	-0.210	0.833	0.022	0.029	0.750	0.455
Indicator for Public Stock Company	-0.040	0.053	-0.760	0.450	-0.001	0.027	-0.020	0.982
Product Mix								
Percent losses incurred in Commercial Short Tail	0.007	0.094	0.070	0.944	0.006	0.019	0.290	0.775
Percent losses incurred in Personal Long Tail	0.022	0.106	0.210	0.836	**-0.085**	0.037	-2.300	0.022
Percent losses incurred in Commercial Long Tail	0.029	0.086	0.340	0.736	-0.001	0.012	-0.100	0.919
Product Line Herfindahl	0.016	0.054	0.300	0.768	0.000	0.000	0.270	0.785
Geographic Herfindahl	-0.053	0.044	-1.200	0.232	**-0.057**	0.037	-1.540	0.124
Efficiency								
Revenue Efficiency	0.063	0.050	1.270	0.206	0.020	0.049	0.410	0.681
Size								
Log of Total Assets	**-0.365**	0.174	-2.100	0.037	**0.293**	0.115	2.550	0.011
Log of Total Assets2	**0.011**	0.005	2.190	0.029	**-0.008**	0.003	-2.750	0.006
Growth								
Net Premium Written Growth Rate * 100	0.000	0.000	-0.820	0.413	0.000	0.000	0.550	0.585
Income & Tax								
Value of Tax Shield 3 Year (Weiss)	0.007	0.006	1.150	0.252	**0.0002**	0.000	5.740	0.000
Smooth -- MA 3 Year (Net Income/Assets)	0.056	0.303	0.190	0.853	-0.269	0.245	-1.100	0.272
Smooth 2--Indicator for Net Income (t-1) < 0	0.015	0.020	0.730	0.463	**-0.027**	0.016	-1.740	0.081
Solvency and Regulation								
Prob of Failure (t-1)	-0.120	0.635	-0.190	0.850	-0.861	0.649	-1.330	0.185
Pct Prems Earned in Regulated Lines in Prior Approval State	0.000	0.053	0.000	0.998	0.027	0.039	0.710	0.478
Incentive to Under Reserve	**0.065**	0.031	2.100	0.036	**-0.019**	0.009	-2.210	0.027
Incentive to Under Reserve Prior to 1993	-0.009	0.032	-0.300	0.766	**0.018**	0.009	1.950	0.052
Best Rating: C++ or C+	-0.112	0.081	-1.380	0.168	-0.046	0.110	-0.410	0.679
Best Rating: B or B-	**-0.081**	0.039	-2.050	0.041	-0.043	0.060	-0.710	0.477
Best Rating: B+ or B++	-0.084	0.040	-2.080	0.038	-0.008	0.045	-0.190	0.852
Best Rating: A or A-	**-0.109**	0.040	-2.750	0.006	-0.019	0.043	-0.440	0.658
Best Rating: A+ or A++	**-0.107**	0.053	-2.030	0.043	-0.019	0.047	-0.410	0.683
Year Indicators Omitted								
ρ	0.779				0.6594			
N	327				5383			
R^2	0.193				0.019			

Table 8. Panel B. Kazinski, Feldhaus, & Schnieder Reserving Error for Three Years. Dependent Varaible is the Absolute Value of the Loss Reserve Error as a Percentage of Total Assets. Estimates from Prais- Whinsten Regression.

	Magnitude of Under Reserving				**Magnitude of Over Reserving**			
	Coef	Std. Error	t	prob > t	Coef	Std. Error	t	prob > t
Intercept	-0.990	1.601	-0.620	0.536	0.063	0.088	0.720	0.472
Indicator for Mutual	-0.019	0.048	-0.400	0.688	-0.002	0.002	-0.740	0.457
Indicator for Reciprocal	-0.005	0.149	-0.040	0.971	0.005	0.006	0.830	0.404
Indicator for RRG	-0.123	0.771	-0.160	0.873	**0.091**	0.020	4.580	0.000
Indicator for Lloyds	-0.007	0.173	-0.040	0.966	-0.011	0.011	-0.950	0.342
Indicator for Direct Writer	-0.010	0.058	-0.170	0.861	0.002	0.003	0.570	0.569
Indicator for Member of a Group	0.023	0.050	0.460	0.647	**-0.005**	0.003	-2.170	0.030
Indicator for Public Stock Company	-0.017	0.047	-0.370	0.710	-0.003	0.002	-1.260	0.208
Product Mix								
Percent losses incurred in Commercial Short Tail	0.011	0.019	0.550	0.581	0.002	0.002	1.270	0.205
Percent losses incurred in Personal Long Tail	-0.029	0.038	-0.770	0.439	**-0.014**	0.004	-3.960	0.000
Percent losses incurred in Commercial Long Tail	-0.001	0.019	-0.050	0.960	-0.004	0.002	-1.680	0.092
Product Line Herfindahl	0.000	0.000	-0.260	0.792	**0.024**	0.004	5.930	0.000
Geographic Herfindahl	-0.072	0.060	-1.210	0.228	**0.011**	0.003	3.470	0.001
Efficiency								
Revenue Efficiency	0.064	0.085	0.760	0.449	-0.002	0.004	-0.460	0.648
Size								
Log of Total Assets	0.154	0.169	0.910	0.363	0.000	0.009	-0.030	0.973
Log of Total Assets2	-0.005	0.004	-1.110	0.267	0.000	0.000	-0.040	0.971
Growth								
Net Premium Written Growth Rate * 100	0.000	0.000	-0.070	0.944	0.000	0.000	-0.160	0.872
Income & Tax								
Value of Tax Shield 3 Year (Weiss)	**0.0001**	0.00004	2.220	0.026	0.000	0.000	0.190	0.848
Smooth -- MA 3 Year (Net Income/Assets)	-0.214	0.448	-0.480	0.634	0.011	0.021	0.530	0.596
Smooth 2--Indicator for Net Income (t-1) < 0	-0.044	0.030	-1.440	0.150	**-0.003**	0.002	-1.860	0.063
Solvency and Regulation								
Prob of Failure (t-1)	-1.180	1.104	-1.070	0.285	0.091	0.061	1.480	0.140
Pct Prems Earned in Regulated Lines in Prior Appro	0.031	0.067	0.460	0.644	0.004	0.003	1.260	0.208
Incentive to Under Reserve	**0.035**	0.030	1.170	0.242	**0.019**	0.001	14.810	0.000
Incentive to Under Reserve Prior to 1993	0.020	0.034	0.570	0.569	0.000	0.001	-0.300	0.767
Best Rating: C++ or C+	-0.022	0.155	-0.140	0.888	**-0.021**	0.012	-1.690	0.091
Best Rating: B or B-	-0.052	0.088	-0.590	0.556	**-0.022**	0.005	-4.190	0.000
Best Rating: B+ or B++	-0.052	0.072	-0.720	0.469	**-0.025**	0.004	-6.170	0.000
Best Rating: A or A-	-0.071	0.070	-1.020	0.309	**-0.025**	0.004	-6.290	0.000
Best Rating: A+ or A++	-0.072	0.077	-0.920	0.356	**-0.027**	0.004	-6.400	0.000
Year Indicators Omitted								
ρ	0.5685				0.5818			
N	2971				5427			
R^2	0.012				0.197			

Table 8. Panel C. Weiss Reserving Error for Five Years. Dependent Varaible is the Absolute Value of the Loss Reserve Error as a Percentage of Total Assets. Estimates from Prais- Whinsten Regression.

	Magnitude of Under Reserving				Magnitude of Over Reserving			
	Coef	Std. Error	t	prob > t	Coef	Std. Error	t	prob > t
Intercept	2.225	1.379	1.610	0.107	9.582	8.790	1.090	0.276
Indicator for Mutual	0.012	0.017	0.670	0.505	-0.092	0.223	-0.410	0.679
Indicator for Reciprocal	-0.001	0.057	-0.020	0.986	-0.026	0.549	-0.050	0.963
Indicator for RRG					-0.211	2.179	-0.100	0.923
Indicator for Lloyds	-0.043	0.164	-0.260	0.794	-0.246	1.053	-0.230	0.815
Indicator for Direct Writer	0.009	0.036	0.260	0.795	0.005	0.260	0.020	0.985
Indicator for Member of a Group	0.012	0.021	0.590	0.557	0.226	0.252	0.890	0.371
Indicator for Public Stock Company	-0.010	0.021	-0.500	0.617	-0.129	0.245	-0.530	0.598
Product Mix								
Percent losses incurred in Commercial Short Tail	0.010	0.052	0.200	0.841	-0.158	0.201	-0.790	0.432
Percent losses incurred in Personal Long Tail	-0.065	0.062	-1.060	0.289	-0.295	0.347	-0.850	0.396
Percent losses incurred in Commercial Long Tail	-0.036	0.049	-0.750	0.455	0.090	0.123	0.730	0.464
Product Line Herfindahl	-0.022	0.022	-1.020	0.309	0.000	0.000	0.000	0.998
Geographic Herfindahl	-0.058	0.036	-1.620	0.107	0.050	0.298	0.170	0.865
Efficiency								
Revenue Efficiency	0.040	0.028	1.440	0.151	-0.301	0.499	-0.600	0.546
Size								
Log of Total Assets	-0.213	0.152	-1.400	0.161	-0.921	0.922	-1.000	0.318
Log of Total Assets2	0.005	0.004	1.290	0.197	0.022	0.024	0.910	0.365
Growth								
Net Premium Written Growth Rate * 100	0.000	0.000	-0.290	0.770	0.000	0.000	0.090	0.928
Income & Tax								
Value of Tax Shield 5 Year	0.000	0.002	-0.030	0.980	0.000	0.000	0.430	0.670
Smooth -- MA 3 Year (Net Income/Assets)	-0.019	0.192	-0.100	0.923	-0.392	2.239	-0.180	0.861
Smooth 2--Indicator for Net Income (t-1) < 0	0.018	0.009	2.080	0.038	-0.089	0.175	-0.510	0.612
Solvency and Regulation								
Prob of Failure (t-1)	-0.017	0.414	-0.040	0.967	-1.856	6.165	-0.300	0.763
Pct Prems Earned in Regulated Lines in Prior Appro	0.015	0.033	0.440	0.657	-0.051	0.339	-0.150	0.881
Incentive to Under Reserve	**0.034**	0.005	6.380	0.000	-0.029	0.059	-0.480	0.628
Incentive to Under Reserve Prior to 1993	**-0.018**	0.005	-3.480	0.001	0.035	0.060	0.600	0.551
Best Rating: C++ or C+	-0.108	0.065	-1.640	0.101	-0.035	1.254	-0.030	0.978
Best Rating: B or B-	**-0.040**	0.023	-1.710	0.087	-0.055	0.584	-0.090	0.925
Best Rating: B+ or B++	-0.030	0.023	-1.300	0.193	-0.011	0.434	-0.030	0.980
Best Rating: A or A-	-0.045	0.026	-1.740	0.082	0.160	0.404	0.390	0.693
Best Rating: A+ or A++	-0.061	0.033	-1.860	0.063	0.055	0.435	0.130	0.899
Year Indicators Omitted								
ρ	0.9373				0.4427			
N	661				4967			
R^2	0.1267				0.003			

Table 8. Panel D. Kazinski, Feldhaus, & Schnieder Reserving Error for Five Years. Dependent Varaible is the Absolute Value of the Loss Reserve Error as a Percentage of Total Assets. Estimates from Prais- Whinsten Regression.

	Magnitude of Under Reserving				**Magnitude of Over Reserving**			
	Coef	Std. Error	t	prob > t	Coef	Std. Error	t	prob > t
Intercept	-4.588	3.476	-1.320	0.187	12.805	6.057	2.110	0.035
Indicator for Mutual	-0.054	0.093	-0.590	0.558	-0.207	0.177	-1.170	0.240
Indicator for Reciprocal	0.078	0.325	0.240	0.811	-0.079	0.370	-0.210	0.831
Indicator for RRG	-0.157	1.230	-0.130	0.898	-0.176	3.518	-0.050	0.960
Indicator for Lloyds	-0.041	0.361	-0.110	0.910	-0.356	0.767	-0.460	0.642
Indicator for Direct Writer	0.032	0.116	0.280	0.780	0.013	0.158	0.080	0.933
Indicator for Member of a Group	0.068	0.101	0.670	0.503	0.192	0.164	1.170	0.241
Indicator for Public Stock Company	0.026	0.097	0.270	0.790	-0.193	0.163	-1.180	0.236
Product Mix								
Percent losses incurred in Commercial Short Tail	-0.006	0.135	-0.050	0.964	-0.172	0.189	-0.910	0.364
Percent losses incurred in Personal Long Tail	-0.109	0.139	-0.790	0.431	0.267	0.300	0.890	0.374
Percent losses incurred in Commercial Long Tail	-0.015	0.031	-0.490	0.628	0.185	0.239	0.770	0.439
Product Line Herfindahl	**-0.276**	0.129	-2.130	0.033	0.000	0.000	-0.050	0.961
Geographic Herfindahl	**-0.253**	0.123	-2.050	0.040	-0.055	0.187	-0.300	0.767
Efficiency								
Revenue Efficiency	0.074	0.185	0.400	0.690	-0.438	0.524	-0.840	0.403
Size								
Log of Total Assets	**0.639**	0.364	1.750	0.080	**-1.241**	0.622	-2.000	0.046
Log of Total Assets2	**-0.020**	0.010	-2.100	0.035	**0.029**	0.016	1.840	0.066
Growth								
Net Premium Written Growth Rate * 100	0.000	0.000	0.180	0.859	0.000	0.000	-0.130	0.894
Income & Tax								
Value of Tax Shield 3 Year (Weiss)	**0.0004**	0.000	4.510	0.000	0.000	0.008	0.000	0.998
Smooth -- MA 3 Year (Net Income/Assets)	-0.686	0.954	-0.720	0.472	0.144	1.697	0.080	0.932
Smooth 2--Indicator for Net Income (t-1) < 0	**-0.129**	0.054	-2.400	0.017	-0.280	0.225	-1.240	0.213
Solvency and Regulation								
Prob of Failure (t-1)	-2.400	2.232	-1.080	0.282	-5.973	8.358	-0.710	0.475
Pct Prems Earned in Regulated Lines in Prior Appr	0.175	0.141	1.240	0.214	-0.045	0.221	-0.200	0.840
Incentive to Under Reserve	**0.103**	0.042	2.460	0.014	0.031	0.119	0.260	0.798
Incentive to Under Reserve Prior to 1993	-0.016	0.050	-0.310	0.754	0.014	0.141	0.100	0.921
Best Rating: C++ or C+	-0.070	0.275	-0.260	0.798	0.080	2.257	0.040	0.972
Best Rating: B or B-	-0.081	0.171	-0.480	0.633	-0.036	0.485	-0.070	0.941
Best Rating: B+ or B++	0.006	0.139	0.040	0.966	0.030	0.382	0.080	0.937
Best Rating: A or A-	-0.111	0.134	-0.830	0.407	0.174	0.356	0.490	0.625
Best Rating: A+ or A++	-0.105	0.151	-0.690	0.488	0.078	0.373	0.210	0.835
Year Indicators Omitted								
ρ	0.681				-0.7683			
N	1988				3638			
R^2	0.041				0.006			

Table 9. Examination of Influences on Deviations from Expected Ratio of IBNR to Total Reserves. Dependent Variable is the Absolute Value of the Error Term from a Regression that Predicts IBNR/Total Reserves. Estimates from Prais-Whinsten Regression.

Panel A. Three Year Period	**W Error 3 Year**				**KFS Error 3 Year**			
	Under Expected IBNR/Total		Over Expected IBNR/Total		Under Expected IBNR/Total		Over Expected IBNR/Total	
Variable Name								
Intercept	0.023		0.036		0.022		0.036	
	(0.004)	***	(0.002)	***	(0.004)	***	(0.002)	***
Tax								
Value of Tax Shield 5 year (KFS)	0.00001		0.00001		-0.00002		0.00001	
	(0.000)	***	(0.000)	***	(0.000)		(0.000)	***
Growth								
Net Premium Written Growth Rate * 100	0.000		0.000		0.000		0.000	
	(0.000)		(0.000)	***	(0.000)		(0.000)	***
Smooth								
Smooth -- MA 3 Year (Net Income/Assets)	0.115		-0.039		0.117		-0.038	
	(0.023)	***	(0.025)		(0.023)	***	(0.025)	
Smooth 2--Indicator for Net Income (t-1) < 0	-0.003		0.001		-0.003		0.001	
	(0.001)	***	(0.002)		(0.001)	***	(0.002)	
Efficiency								
Revenue Efficiency	0.020		-0.035		0.021		-0.035	
	(0.003)	***	(0.005)	***	(0.003)	***	(0.005)	***
Regulation								
Prob of Failure (t-1)	0.161		0.048		0.164		0.065	
	(0.042)	***	(0.067)		(0.041)	***	(0.067)	
Pct Prems Earned in Regulated Lines in Prior Approval State	0.002		-0.009		0.002		-0.009	
	(0.005)		(0.003)	***	(0.005)		(0.003)	***
Difference Between Total Reported Failed Ratios and Failed Managed Ratios	0.000		0.001		0.001		-0.001	
	(0.001)		(0.001)		(0.001)		(0.002)	
Difference Between Number of Failed Ratios * Prior to 1993	-0.001		-0.001		-0.003		0.003	
	(0.001)	**	(0.001)		(0.001)	***	(0.002)	
Indicator for Public Stock Company	-0.001		0.003		-0.002		0.003	
	(0.002)		(0.003)		(0.002)		(0.003)	
Rho	0.989		0.204		0.989		0.203	
N	4076		4322		4076		4322	
R^2	0.03		0.92		0.03		0.92	

Table 9. Examination of Influences on Deviations from Expected Ratio of IBNR to Total Reserves. Dependent Variable is the Absolute Value of the Error Term from a Regression that Predicts IBNR/Total Reserves. Estimates from Prais-Whinsten Regression.

Panel B. Five Year Period	**W Error 5 Year**		**KFS Error 5 Year**	
	Under Expected IBNR/Total	Over Expected IBNR/Total	Under Expected IBNR/Total	Over Expected IBNR/Total
Variable Name				
Intercept	0.041	0.038	0.039	0.037
	(0.003) ***	(0.002) ***	(0.003) ***	(0.002) ***
Tax				
Value of the Tax Shield for 5 Year Error	-0.00001	0.000	-0.00001	0.000
Growth				
Net Premium Written Growth Rate * 100	0.000	0.000	0.000	0.000
	(0.000) **	(0.000) ***	(0.000) **	(0.000) ***
Smooth				
Smooth -- MA 3 Year (Net Income/Assets)	0.074	0.005	0.077	0.005
	(0.028) ***	(0.024)	(0.029) ***	(0.024)
Smooth 2--Indicator for Net Income (t-1) < 0	0.003	0.005	0.004	0.006
	(0.003)	(0.002) **	(0.003)	(0.002) ***
Efficiency				
Revenue Efficiency	0.020	-0.035	0.021	-0.035
	(0.003) ***	(0.005) ***	(0.003) ***	(0.005) ***
Regulation				
Prob of Failure (t-1)	0.281	0.377	0.337	0.356
	(0.105) ***	(0.059) ***	(0.107) ***	(0.059) ***
Pct Prems Earned in Regulated Lines in Prior Approval State	-0.035	-0.013	-0.035	-0.012
	(0.005) ***	(0.003) ***	(0.005) ***	(0.003) ***
Incentive to Under Reserve	-0.002	0.002	-0.006	0.006
	(0.001) *	(0.001) ***	(0.003) **	(0.001) ***
Incentive to Under Reserve* Prior to 1993	0.000	-0.004	0.007	-0.008
	(0.001)	(0.001) ***	(0.003) **	(0.001) ***
Indicator for Public Stock Company	0.002	0.004	0.001	0.003
	(0.004)	(0.003)	(0.004)	(0.003)
Rho	0.717	0.390	0.712	0.387
N	2235	3296	2235	3297
R^2	0.033	0.098	0.033	0.098

Note: Bolded Variables are constructed with different measures of the error which reflect the column headings..

Figure 1. Derivation of 3 Year Reserve Errors From NAIC P/L Statement Schedule P- Part 2 - Summary

Schedule P - Part 2 - Summary

1 Years in Which Losses Were Incurred	Incurred Losses and Allocated Expenses Reported at Year End ($000 Omitted) 2 Y_{T-9}	3 Y_{T-8}	4 Y_{T-7}	5 Y_{T-6}	6 Y_{T-5}	7 Y_{T-4}	8 Y_{T-3}	9 Y_{T-2}	10 Y_{T-1}	11 Y_T	12 One Year	13 Two Year
1. Prior	**000**										XXXX	XXXX
2. Y_{T-9}											XXXX	XXXX
3. Y_{T-8}	XXXX										XXXX	XXXX
4. Y_{T-7}	XXXX	XXXX			$\mathcal{A}_5$						XXXX	XXXX
5. Y_{T-6}	XXXX	XXXX	XXXX				$\mathcal{A}_3$			$\mathcal{B}$	XXXX	XXXX
6. Y_{T-5}	XXXX	XXXX	XXXX	XXXX							XXXX	XXXX
7. Y_{T-4}	XXXX	XXXX	XXXX	XXXX	XXXX						XXXX	XXXX
8. Y_{T-3}	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX					XXXX	XXXX
9. Y_{T-2}	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX				XXXX	XXXX
10. Y_{T-1}	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			XXXX	XXXX
11. Y_T	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		XXXX	XXXX

Schedule P - Part 3 - Summary

1 Years in Which Losses Were Incurred	Cumulative Paid Losses and Allocated Expenses at Year End ($000 Omitted) 2 Y_{T-9}	3 Y_{T-8}	4 Y_{T-7}	5 Y_{T-6}	6 Y_{T-5}	7 Y_{T-4}	8 Y_{T-3}	9 Y_{T-2}	10 Y_{T-1}	11 Y_T	12 Number of Claims Closed with Loss Payment	13 Number of Claims Closed without Loss Payment
1. Prior												
2. Y_{T-9}											XXXX	XXXX
3. Y_{T-8}	XXXX										XXXX	XXXX
4. Y_{T-7}	XXXX	XXXX			$\mathcal{C}_5$						XXXX	XXXX
5. Y_{T-6}	XXXX	XXXX	XXXX				$\mathcal{C}_3$			$\mathcal{D}$	XXXX	XXXX
6. Y_{T-5}	XXXX	XXXX	XXXX	XXXX							XXXX	XXXX
7. Y_{T-4}	XXXX	XXXX	XXXX	XXXX	XXXX						XXXX	XXXX
8. Y_{T-3}	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX					XXXX	XXXX
9. Y_{T-2}	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX				XXXX	XXXX
10. Y_{T-1}	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			XXXX	XXXX
11. Y_T	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		XXXX	XXXX

Schedule P - Part 4 - Summary

1 Years in Which Losses Were Incurred	Bulk and Incurred But Not Reported Reserves on Losses and Allocated Expenses Reported at Year End ($000 Omitted) 2 Y_{T-9}	3 Y_{T-8}	4 Y_{T-7}	5 Y_{T-6}	6 Y_{T-5}	7 Y_{T-4}	8 Y_{T-3}	9 Y_{T-2}	10 Y_{T-1}	11 Y_T
1. Prior	**000**									
2. Y_{T-9}										
3. Y_{T-8}	XXXX									
4. Y_{T-7}	XXXX	XXXX					$\mathcal{E}$			$\mathcal{F}$
5. Y_{T-6}	XXXX	XXXX	XXXX							
6. Y_{T-5}	XXXX	XXXX	XXXX	XXXX						
7. Y_{T-4}	XXXX	XXXX	XXXX	XXXX	XXXX					
8. Y_{T-3}	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX				
9. Y_{T-2}	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			
10. Y_{T-1}	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX		
11. Y_T	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	

Weiss =	Sum ($\mathcal{A}$) - Sum ($\mathcal{D}$)
GP =	Sum ($\mathcal{A}$) - Sum ($\mathcal{B}$)
IBNR Ratio =	Sum ($\mathcal{E}$) / Sum ($\mathcal{A}$)

Figure 2. Distribution of Weiss and KFS Errors (as a percentage of total assets) for 3 and 5 Year Periods over Period 1989-2000

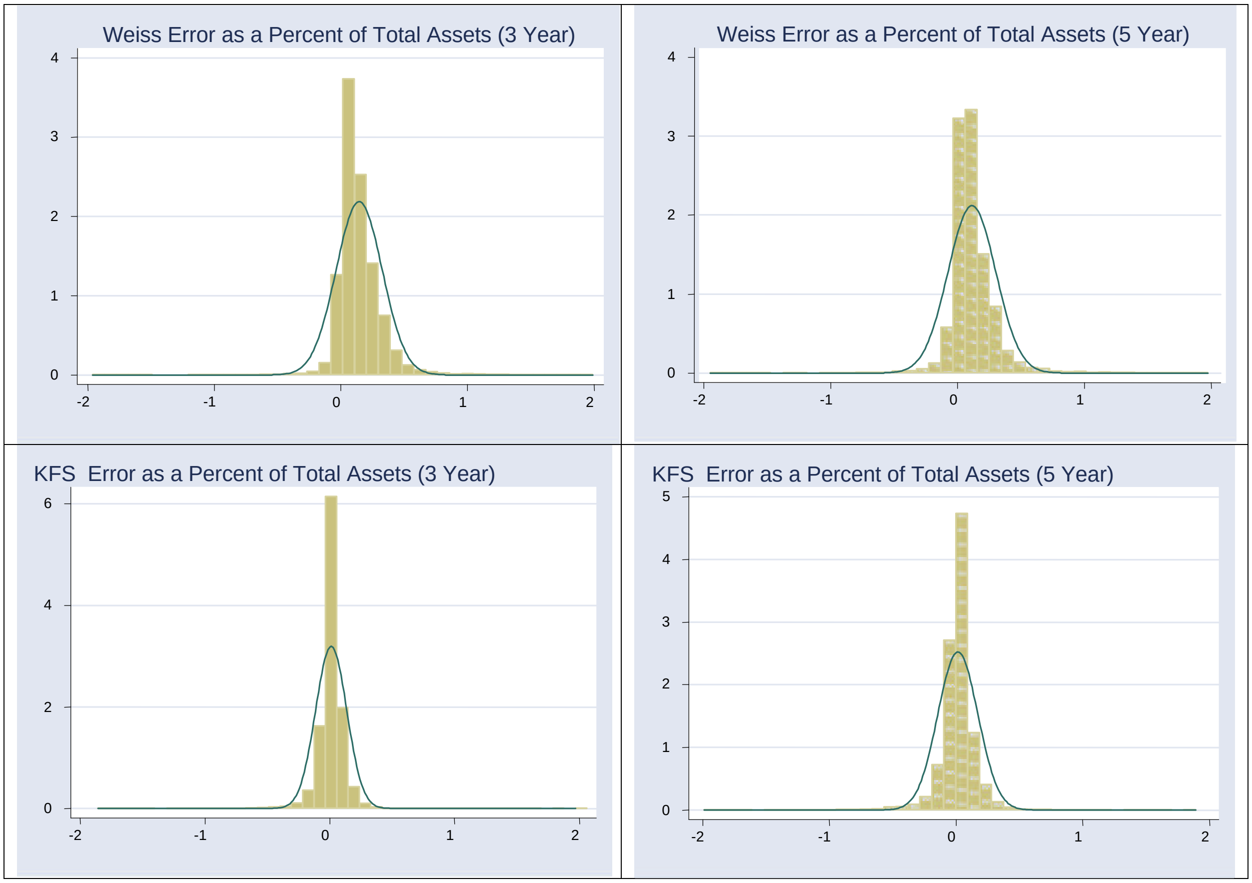
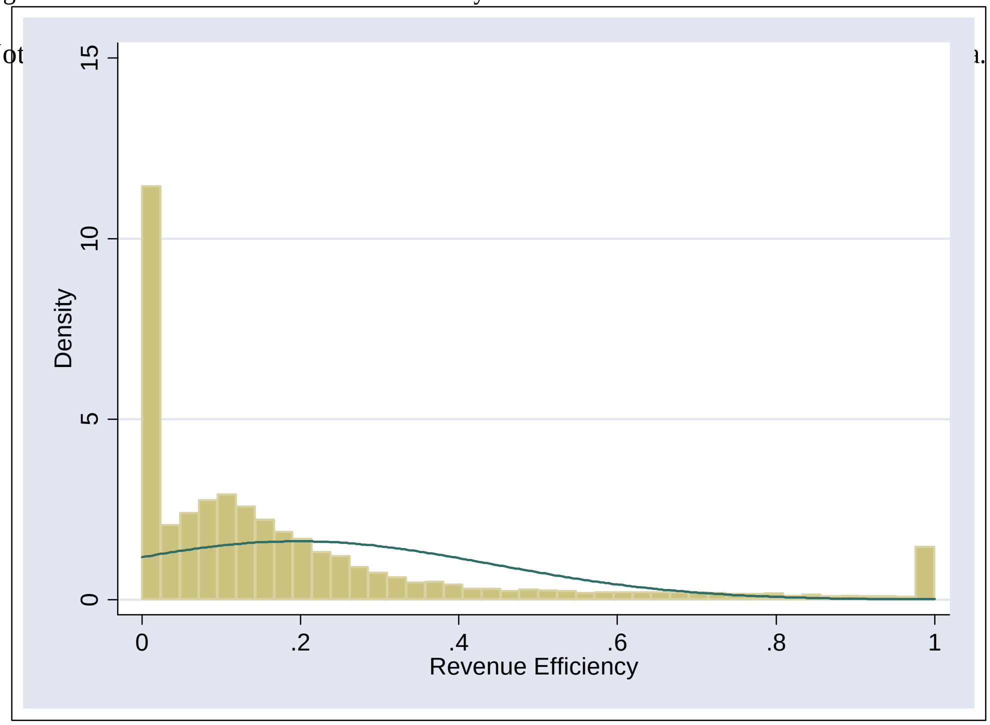


Figure 3. Distribution of Revenue Efficiency from DEA Model of P/C Insures.

Not



a.

Figure 4. Indicators of Financial Weakness over 1990-1999.

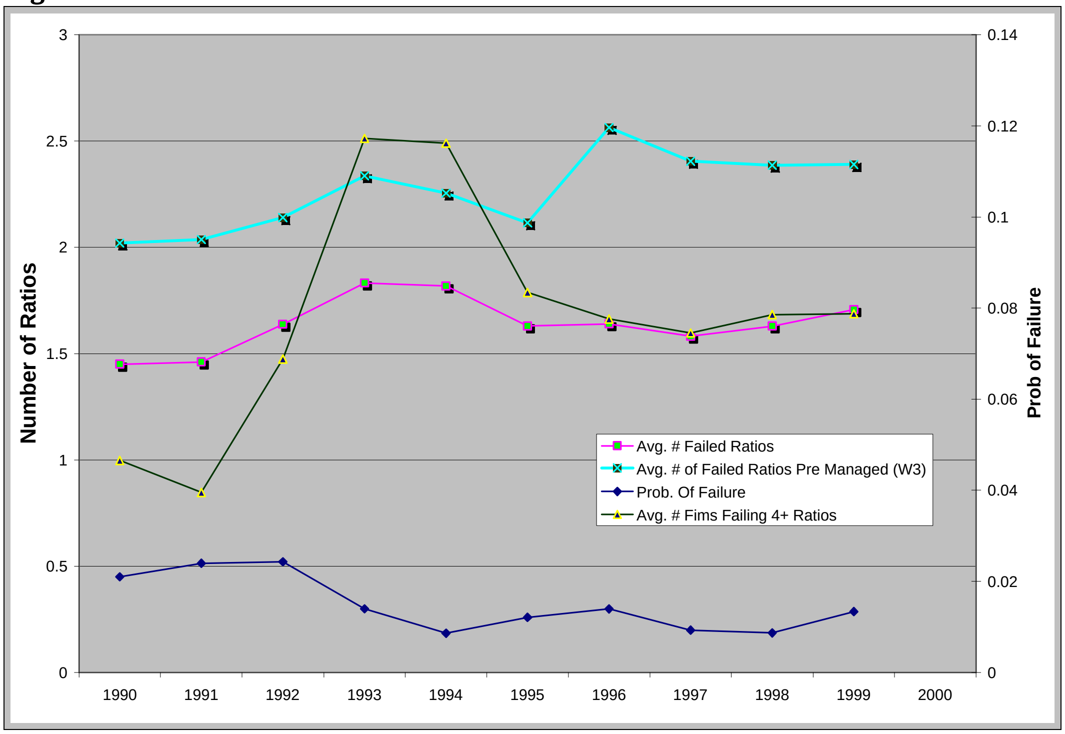
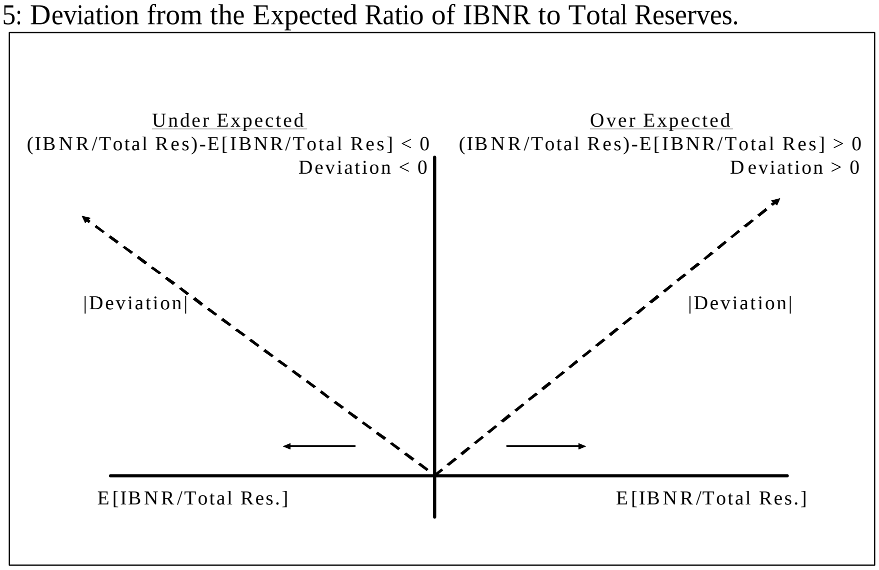


Figure 5: Deviation from the Expected Ratio of IBNR to Total Reserves.



Appendix A – The DEA Methodology

DEA uses a standard linear programming technique to pinpoint peer groups of efficient firms for *each* firm or decision-making unit (DMU) being evaluated. A firm is fully efficient (efficiency of 1.0) if it lies on the frontier and inefficient (efficiency < 1) if it is not on the frontier, which means that its outputs could be produced more efficiently by another firm or firms.

DEA total technical efficiency is measured by estimating "best-practice" production frontiers, utilizing the input-oriented distance function (Shephard, 1970). Suppose producers use input vector $x = (x_1, x_2, ..., x_k)^T \in \Re_+^k$ to produce output vector $y = (y_1, y_2, ..., y_n)^T \in \Re_+^n$, where T denotes the vector transpose operator. A production technology that converts inputs into outputs can be modeled by an input correspondence $y \rightarrow V(y) \subseteq \Re_+^k$. For any $y \in \Re_+^n$, V(y) denotes the subset of *all* input vectors $x \in \Re_+^k$ which yield at least y. The input-oriented distance function for a specific decision making unit (DMU) is then:

$$D(x, y) = \sup\left\{q : (y, \frac{x}{q}) \in V(y)\right\} = \left(\inf\left\{q : (y, q\,x) \in V(y)\right\}\right)^{-1} \tag{1}$$

The input distance function is the reciprocal of the minimum equi-proportional contraction of the input vector x, given outputs y. Farrell's (1957) measure of input technical efficiency TE(x,y) is equal to $1/$D(x,y).

For each year, technical efficiency is estimated separately for each firm in the sample by solving linear programming problems. There are several different ways to present DEA technical efficiency linear programming problems. The simplest representation for firm *s* is the following:

$$\begin{aligned} &\left(\mathrm{D}(x_s, y_s)\right)^{-1} = \mathrm{TE}(x_s, y_s) = \min q_s \\ &\text{subject to: } Y\,l_s \geq y_s,\ \mathrm{X}\,l_s \leq q_s x_s,\ l_s \geq 0 \end{aligned} \tag{2}$$

where *s*=1,2,…,S for each year. Y is an N x S output matrix and X is a M x S input matrix for all DMU's in the sample; y_s is an N x 1 output vector and x_s is an M x 1 input vector for firm s; and finally l_s is an S x 1 intensity vector for firm s. The constraint $l_s \geq 0$ imposes constant returns to scale (CRS). DMU's with elements of l_s that are non-zero are the set of "best-practice" reference DMU's for the firm under analysis.

A producers' objective is assumed to be the maximization of revenue, subject to the constraints imposed by output prices, input supplies, and the structure of the production technology. Accordingly, we utilize an output-oriented model instead of the input-oriented approaches characterized above. The linear programming problem is solved for each firm for each year in the sample:

$$\begin{aligned} &\underset{y_s}{Max} \sum_{i=1}^{N} p_{si} y_{si} \\ &\text{Subject to } Y?_s \geq y_i ,\ i = 1,2,...,N \\ &X?_s \leq x_j ,\ j = 1,2,...,M \\ &\text{and } ?_s \geq 0 \end{aligned} \qquad (4)$$

The solution vector y_s^* is the revenue maximizing output vector for the output price vector p_s and the input vector x_s. Similar to the calculation of cost efficiency, the second step in the procedure is to compute firm s's revenue efficiency as the ratio of observed revenue to maximum possible revenue-- $Eff_{revenue} = \frac{p_s^T y_s}{p_s^T y_s^*}$. Revenue efficiency is less than or equal to 1. A score equal to 1 indicates that the firm is fully revenue efficient. Any score that diverges from 1 implies that the firm could produce more outputs, with the same about of inputs, than are actually produced.

Appendix B: Production Approach - Input and Output Measures

Quantity	Price
Outputs	
Risk-Pooling and "Real" Services Output	**Risk-Pooling and "Real" Services Output**
Present Value of Real Losses Incurred -personal short-tail lines -personal long-tail lines -commercial short-tail lines -commercial long-tail lines	Price =(Premiums Earned - PV(LI)) / PV(LI)
Financial Intermediation Output	**Financial Intermediation Output**
Average Real Invested Assets	Expected Rate of Return on the Insurer's Assets -Expected ROR on Invested Assets is the weighted average of the expected return on debt and the expected return on equity -Expected ROR on Equity is the 90-day T-bill rate plus Ibbotsons' average market risk premium on large company stocks -Expected ROR on Debt is the ratio of actual investment income (minus dividends on stock) to insurer holding of debt instruments
Inputs	
Adminstrative Labor	**Adminstrative Labor**
Total Administration and Manager Labor Expenses/Input Price	Real Avg Weekly Wages SIC 6311
Agent Labor	**Agent Labor**
Total Acquisition Expenses/Input Price	Real Avg. Weekly Wages SIC 6411
Materials & Business Services	**Materials & Business Services**
All Non Labor Expenses/Input Price	Real Avg. Weekly Wages SIC 7300
Financial Equity Capital	**Financial Equity Capital**
Real Equity Capital (Surplus)	Average 90-day Treasury bill rate in year t, plus the long-term (1926 to the end of year t) average market risk premium on large company stocks from Ibbotson Associates
Debt Capital	**Debt Capital**
Real Loss Reserves and Unearned Premium Reserves	Investment Income Attributed to PH / Input Quantity