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The Geneva Association - General Secretariat - 53, route de Malagnou - CH-1208 Geneva
Tel.: +41-22-707 66 00 - Fax: +41-22-736 75 36 - secretariat@genevaassociation.org - www.genevaassociation.org

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

By

Martin F. Grace
James S. Kemper Professor
Department of Risk Management
Georgia State University
PO Box 4035
Atlanta, Georgia 30302-4035
mgrace@gsu.edu

J. Tyler Leverty
Assistant Professor
Department of Finance
University of Iowa
Iowa City, Iowa

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 or the smoothing of income), manipulation (to avoid regulatory scrutiny or 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. First, 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. Second, we include a proxy for managerial efficiency. Third, we examine whether IBNR reserves are the sources of claim manipulation. Overall we find that the principal motivation for loss reserving errors is related to rational profit maximizing behavior rather than solvency manipulation. In addition, contrary to previous findings, we discover that insurers with a relatively higher percentage of premiums in regulated lines in prior approval states tend to over-reserve relative to other insurers.

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

By Martin F. Grace and J. Tyler Leverty

> "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.
>
> "'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 whether AIG under-reserved against future claims to meet current earnings expectations. Loss reserves are collectively the largest liability on a property-liability insurers' balance sheet and any under-reserving of losses decreases an insurer's liabilities and thus boosts 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 the media

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

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 and uncertainty. 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 is comprised 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.

Given the uncertainties involved in estimating loss reserves it is conceivable that reserve errors result from a firm's failure to take account of all the information available. Developments in litigation and costs can change greatly 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 rates (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 violations decreases due to under-reserving does not necessarily indicate that the original motivation of the under-reserving was to appear solvent to avoid regulatory scrutiny.

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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.

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 accounting discretion in reporting earnings. The practical importance of such an understanding is valuable both 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 accruals 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, to signal firm quality, to respond to solvency and regulatory price incentives, and to the extent it makes sense smooth income over low and high income temporal states of the world.

This paper differs from previous research on loss reserves in a number of dimensions. First, we holistically 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 which 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 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 seek to explain the differences between under- and over-reserving firms and we analyze the factors that contribute to the likelihood that a firm consistently over-reserves. 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 are more sophisticated reserving incentives and they now have access to better solvency tools that are less influenced by possible reserve manipulation.

We also find evidence that the value of the tax shield is one of the most important drivers for over reserving and is especially related to the magnitude of over reserving. In contrast, taxes have no influence on the likelihood of under reserving or the size of under reserving. Furthermore, we discover that firm's do not conduct their over-reserving for tax purposes with IBNR reserves. We also find, in contrast to the previous literature, that firms operating in highly price regulated environments are more likely to over reserve the greater the percentage of premiums written in that environment, but again these firms do not carry out their over-reserving with IBNR.

[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.

The remainder of the paper is organized as follows. Section 2 provides background information on reserve errors and reviews the extant literature on reserve. It also contains background information on the NAIC's solvency surveillance system and the construction of IRIS ratios that are purged of loss reserve error. Section 3 provides a description of our data and a description of our managerial efficiency and probability of insurer failure measures that we employ in the empirical section. Section 4 describes the hypotheses from the literature, and Section 5 explains our empirical methodologies. 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 1980s tort liability crisis companies such as St. Paul over reserved (in an ex post sense) and when it realized that it had over reserved, it released the reserves as profits to 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 did not change and the entrants had set prices below actuarial costs merely due to a perception of a change in risk caused by St. Paul's actions.[4]

Concerns regarding insurers' proper reserve levels existed prior to the tort crisis of the 1980s. Forbes (1970), in fact, calls for greater regulation and disclosure of reserves presumably to mitigate insolvency. Others such as Weiss (1986) and Grace (1990), however, have pointed out the relationship between reserves and taxes as the IRS has 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

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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.

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 what influences the firm to over or under estimate loss reserves. Essentially there are five main non-mutually exclusive hypotheses:

(1) Income Smoothing Incentives
(2) Economic Conditions
(3) Tax Incentives
(4) Solvency Reserving Incentives
(5) Price Regulation Incentives

Weiss (1985) essentially 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 (unanticipated inflation and interest rates) also influence loss reserve errors.

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

A number of researchers Petroni (1992), Petroni & Beasley (1996), Panalva, (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. There is some regulatory lore which suggests that this number of failures triggers more scrutiny from the state regulator.[6] Gaver and Patterson specifically suggest that managers try to maintain their

[6] As we discuss below, the failure of four or more IRIS ratios does not necessarily bring regulatory review. Furthermore, this failure of four or more ratios is not necessarily sufficient to trigger extra meaningful scrutiny.

IRIS violations to no more than four by intentionally under reserving to avoid regulatory attention.

Finally, Nelson (2000) examines the effect of state 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 or prior approval statutes for rates) discount reserves to a greater degree than other insurers.

2. B Loss Reserve Calculation

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).

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

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

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 valuation of the loss. In Figure 1 the loss reserve is calculated as sum of the elements in the areas $\mathcal{A}_k - \mathcal{D}_k$ (where k is either 3 or 5). In this paper, 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 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 elements contained in the areas $\mathcal{A}_k - \mathcal{B}_k$.

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 information are the *W* measure has a positive mean and 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 requires insurers to describe their accident year loss development over a ten-year period. Over our sample, the percentage of losses paid () at 5 years is approximately 65 percent, while at three years the percentage of losses paid is roughly 70 percent. Thus, as we get closer to the time of resolution, the firm has less discretion.

2C. Insurance Solvency Regulation

One of the major criticisms we levy 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 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 take more scrutiny of the insurer's books. As Petroni (1992) acknowledges and Klein (1995) points out, the IRIS system does not force a regulator to act, it merely suggests various degrees of intervention. Thus this process is more complex and 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 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 using a logistic regression model. They find that a logistic regression model using the individual FAST ratios plus a few addition variables (firm size and organizational form) 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 in the literature that insurers manipulate their loss reserve to not violate four or more IRIS ratios, we construct a set of pre-managed IRIS ratios. The pre-managed ratios are the reported IRIS ratios that 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] [12]. Table 3 presents a definition of each ratio, describes how each ratio is impacted by the loss reserve estimate, and lists the bounds

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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. In addition, the scoring methodology is not publicly available.

[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. $Total\ FAST\ Score = \sum_{i=1}^{25} Score_i(Fast\ Ratio_i)$

[11] The IRIS system traditionally consisted of eleven ratios, but a twelfth ratio was added in 1993

[12] The pre-1993 "usual range" for the ratio added in 1993 is the 1993 prescribed bounds.

for each sample year. 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 understating the loss reserve. Two other ratios are unaffected by loss reserves (IRIS 2 and IRIS 5) and for one ratio the effect of loss reserve error is indeterminate (IRIS 6).

Table 4 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 pre-managed ratios defined using the Weiss and KFS error at three and five years. Understating the loss reserve enhances the probability of having the IRIS ratios within the usual range. However, it is important to note that if number of reported IRIS ratio failures decreases due to under-reserving it does not necessary indicate that the original motivation of the under-reserving was to make the firms appear solvent to reduce the potential for regulatory scrutiny. It is entirely feasible under-reserving could be driven by a completely separate objective (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. 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. Further, if the data do not allow us calculate the efficiency measure (which is relatively data intensive) or the probability of failure measure, or had zero reserves; we also drop them from the sample. 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 because we employ the NAIC's statutory loss reserving data. The major and most important difference between the SAP and GAAP provision is that losses are not discounted. This has the effect of making the firm look more conservative and also 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.

3 A. Variable Construction

Firm efficiency, the manger's ability to marshal resources to generate the most profit or the ability to minimize costs, would seem to have an effect on a firm's decision to choose to manipulate reserves. For example, choosing to increase reserves rather than selling more business may generate opportunity costs. Similarly, firms that under reserve may also be generating an opportunity cost to the owners which could be picked up by our measurement of firm efficiency. Grace and Leverty (2005) show, for example, 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.

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 which have become the state-of-the-art in measuring the performance of business firms and are due to the contributions of 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 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, we can also think of this efficiency measure as 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 how we calculate this measure and Appendix B for a description of the inputs and outputs utilized in the DEA 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.[13]

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 really inefficiency (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)). Appendix B contains a listing of the output measures.

The second variable which we calculate is the probability of failure. Prior definitions of financial distress in the property-liability insurance literature rely on IRIS ratios.[14] 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 model 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

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[13] Leverty (2005) describes in detail the method to calculate the efficiency measure we employ in this paper. We use the particular efficiency measure that is seems to be most related to external measures of a firm's market value. Because most companies in our sample are not publicly traded, the efficiency measure for market values well.

[14] 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).[15] The use of a size variable and a mutual indicator variable is consistent with the extant literature on property-casualty insolvency prediction. 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).

$$I_{jt} = a_0 + f(\text{Size}_{jt}, \text{Mutual}_{jt}, \text{Ratio}_{jt}) + e_{jt} \quad (3)$$

For insurer *j* and data year *t*: I_{jt} is the unobserved propensity to fail subsequent to year *t*,[16] 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 IRIS and FAST ratios.

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 4 or more ratios each year. We also observe that the average number of failed ratios that were pre-managed is also higher than the average number of reported ratio violations.

3 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 organizational form, concentration by line and by state, we also control for size and growth in terms of net premiums written. 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 as 67 percent of the companies are stock companies. Most firms are members of a group (75.4 percent), a small percentage is a direct writer (15.2 percent), and a small percentage is publicly traded (13.4 percent). We also see that if we break down the types of business written into four broad categories, that the average firm has 26 percent of

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[15] 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.

[16] 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.

premiums written in commercial short tail,[17] 36 percent of the average firm's premiums comes from commercial long tail business, 31.4 percent of the average firm's premiums come from personal long tail lines and 10 percent come from personal short tail lines.

In terms of concentration, the average firm has a Herfindahl Index of about .35 which translates to about an average of 3 lines of business. The geographic Herfindahl, the index is approximately .5 which translates to the average firm operating in two states. The average firm size is $558 million in nominal dollars and is approximately 20 percent efficient using our definition of revenue efficiency. The average firm's one year growth rate is approximately 24 percent as measured by the net premiums written.

The average firm has a tax shield as a percent of total assets that ranges between 5.5 and 16.8 percent depending on the measure we employ. The incentive to smooth income measured by the three year average rate of return on assets is approximately 2.6 percent. Further, 19 percent of our sample had negative net income in the previous year.

In terms of our regulatory variables, the average firm has approximately 20 percent of its auto, homeowners, and workers compensation business in lines of business regulated 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 reported IRIS violations and pre-managed violations) we see that incentive is positive for each measure. Finally, we see that a majority of the firms have A.M. Best ratings of at least an A- or above.

4. Received Hypothesis and Discussion

There are essentially four hypotheses from the literature that we focus on in this paper.[18] First, we look at the smoothing incentives faced by the firm. According to the smoothing hypotheses, a firm will attempt to manage its earnings. If profits are unexpectedly higher (lower) in the present period, then the firm will over (under) reserve to keep long run profits in line with expectations.

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 or, more formally,

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

[18] A fifth one, economic conditions, economic conditions are controlled for by our fixed effects estimation. In previous studies, authors (see Weiss (1985)) use a yearly projection of unanticipated inflation. As an alternative, the year fixed effect control for differences in economic conditions across years.

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

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. We expect that if there is a loss, then insurers, if they are smoothing, will over reserve to smooth inter-temporal profits.[19]

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

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

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.

In our third hypothesis we look at the incentives caused by the insurer's solvency prospects. Previous researchers employ some indicator of solvency based upon the number of IRIS ratios failed or the incentive to manage these IRIS Ratios. We have three variables to examine different aspects of this hypothesis. The first is the probability of failure generated from a logit solvency prediction model discussed above. The second is the incentive to under reserve (IUR). This is measured by

$$IUR_t = Sum\ of\ \ Reported\ \ IRIS\ \ Ratio\ Violations_t - Sum\ of\ \ Pre\text{-}Managed\ \ Ratio\ Violated_t .$$

We refer to this as the incentive to under reserve as presumably the firm could manipulate its reserves (by under reserving to increases surplus) to violate fewer IRIS ratio test bounds.

[19] 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 examining this problem.

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 prior given no reserving error. Thus, the greater is the difference between the reported and the pre-managed IRIS violations, the greater is the incentive for the insurer to under reserve.

The third solvency related variable is a dichotomous indicator variable (year prior to 1993) interacted with IUR to account for the change in solvency surveillance that occurred starting with the 1993 reporting year. Prior to 1993, IRIS ratios arguably would matter more to regulators and thus to insurers' incentives to manage their reserves. However, after 1993 the Financial Analyses and Surveillance Tracking (FAST) system was being employed. 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.

We also add one new hypothesis to the literature. This concerns the effect of managerial quality or managerial efficiency on 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 come at a cost to the owners of the firm, so to the extent managers are acting efficiently they should take into account the costs of under or over reserving.

Finally, we look at the effect of regulation on the incentives to reserve. Nelson (2000) hypothesized and found evidence 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 these more heavily regulated lines (auto, homeowner, and workers compensation) in those states with prior approval laws.[20] 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. This is because 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. This can be accomplished by increasing the reserves, so it is possible that insurers respond by raising reserves to ensure that prices are not so low as to cause the firm to sell at a loss.

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

5. Results

5.1 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 (Table 5) and second, we look at the likelihood of over reserving for the five year errors (Table 6). Finally, we analyze the proclivity for firms to be over reserved for the entire sample period (Table 7).

Our first test is shown in Table 5 (for *Weiss* and *KFS* three year errors) where we seek to determine whether over reserving is a result of systematic effects. We estimate a logistic regression model with our variables of interest (Smooth, Tax, Solvency and Regulation) along with other variables that control for size, product mix, organizational form, geographic and business concentration, size, growth, AM Best Ratings and fixed effects for year. Thus, our dependant variable is 1 if the error is positive and is 0 otherwise for both the *W* and *KFS* errors. We find that the tax shield is significantly related to whether a firm over reserves. This is consistent with the prior literature. The smoothing incentive as measured by the three year average return on assets is significant for the *KFS* error, but not the *W* error. The *Smooth 2* incentive is of the correct sign for both errors. 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 which is the number of Reported IRIS ratios the firm violates net of the number of ratios the firm would have violated if there was no reserve error, we see that the incentive to under reserve is positively associated with the likelihood of over reserving. This is contrary to the hypothesis described in the literature, but is consistent with our conjecture that firms determine reserves for reasons other than solvency.

In contrast, we see that the coefficient for the *W* error model on the probability of firm failure is negative and reflects the conjecture that firms in solvency trouble are less able to over reserve. While not significant for the KFS model, the probability of failure is still negative while the coefficient on IUR is positive. We also note there is no significant difference in our terms that measure 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, we see that the percentage of premiums in regulated lines in prior approval states is positively associated with the likelihood of over reserving. This is contrary to Nelson's (2000) hypothesis, 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 from five years prior to resolution. Generally, we see the value of the tax shield is positive and significantly related to the likelihood of over reserving. The smoothing incentive variables are of the correct sign and significant for both errors. Further, incentive to under reserve (IUR) is significant for the Weiss error but not for the KFS error. However, it is once again of the wrong sign. In neither case is the probability of failure significantly related to the likelihood of over reserving. Taken together with the results from Table 5, this suggests that the probability of failure 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. Again, this is evidence in favor of our alternative hypothesis.

After looking at the propensity to over reserve in any given year, we decided to look at those companies which over reserved for the entire period (1989-1999). This group of over 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.

First, we see that 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 three of the measures (*W3*, *KFS3*, and *KFS5*) we see a positive relationship between the likelihood of over reserving and the value of the tax shield. Further, the smoothing incentive as measured by the past average return on assets is consistently positive for these three models. We also find that the *Smooth 2* (a loss in the previous year) measure is positive and significantly related to over reserving for the three models. Both of these smoothing incentive measures do not seem to be testing the smoothing incentives. These incentives seem to be related to consistent over reserving and that seems hard to justify and are contrary to expectations 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 for most models. This suggests that prior to 1993, for firms which consistently over reserved the incentive to under reserve by manipulating the IRIS ratios actually mattered. However, these coefficients are significant in *W3* and *KFS5* only.

In terms of efficiency, we see evidence that more efficient firms are less likely to be over reserving throughout the period at the three year error level. In both the *W3* and the *KFS3* model the coefficient on the revenue efficiency measure is negative and significant. While it is positive in the *W5* error, we are concerned that the number of over reserved companies is too small to rely upon this result. Finally, for the percent in regulated lines, we see a positive relationship only in the *W3* model.[21]

5.2 Magnitude of Over Reserving

Our next set of tests is shown in Table 8 Panel A- Panel D. These tests concern the size of the reserve error. We take the reserve error's absolute value and then regress it against a similar set of variables to assess how the magnitude to the loss relates to these explanatory variables. Others have used a somewhat similar procedure where they take the absolute value of the error and then regress it against a model like the following (see e.g. Browne et al. (2004) or Beaver et al. (2003)):

$$ABS(Error) = a + Pos\_Error*(B_1X) + Neg\_Error*(B_2X) + e \qquad (4)$$

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. This is likely to be a misspecification of the positive/negative error generating process as it is likely that positive

[21] We plan on looking at a less restrictive test such as examining those companies that were over reserved during some significant part of the 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) fifty percent of the time.

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:

$$\begin{aligned} ABS(Error) &= a_1 + b_1 X + x_1 \text{ if } Error < 0 \\ ABS(Error) &= a_2 + b_2 X + x_2 \text{ if } Error > 0 \end{aligned} . \qquad (5)$$

We can verify whether equation (5) is preferred by using a Wald Test. In fact, we find that in all four cases (*W3, W5, KFS3, and KFS5*) the null hypothesis that the restrictions in equation (4) dominate the unconstrained (5) is rejected at the 0.01 level.

In Table 8 panel A we examine the magnitude of under and over reserving. If we look at under reserving, the only significant variables are the smoothing indicator which is negative and the incentive to under reserve which is positive. If the firm is under reserved and it experiences a rise in its three year average return on assets, then it could conceivably increase reserves and thus reduce the magnitude of its under reserving. This is what we see for the *W3* error. This finding is intuitively appealing, but it is not consistent with the smoothing hypothesis which suggests that an increase in three year average return on assets would generate a higher magnitude of under reserving. For the incentive to under reserve, we find the sign is correct. However, this is troublesome because it is not significant for the pre - 1993 period. If we believe the UIR should be related to the incentive to under serve, it should be most evident in the pre-1993 era if it is evident at all.

For the case of the magnitude of over reserving, we see that taxes matter. As the value of the tax shield increases we see the size of the positive loss reserve error (i.e. over reserve) increase. *Smooth 2* is also significant which suggest firms respond to a loss by increasing the size of over reserving to reduce the deviation from income expectations.

In Panel B we examine the *KFS3* error. Nothing is significant in the regression estimating the magnitude of the under reserving. Once again, for the reserving magnitude regression the value of the tax shield matters as does the *Smooth 2* incentive. We also note that firms with an increase in the probability of failure seek to increase their magnitude of their over reserving. We do not see this in other regressions but it does suggest that some firms react to the increased likelihood of default by increasing their reserves. Finally, our measure of the under reserving incentive is positive and again the wrong sign.

Panel C shows the *W5* error. We see that once again relatively few variables explain the size of the under reserving. However, the incentive to under reserve is significant and of the correct sign, but the hypothesis is still questionable given the sign of the 1993 interaction term as FAST went into effect after 1993. For the magnitude of the over reserving, once again we see that only taxes matter.

Finally, Panel D shows the *KFS 5* year error models. We see the same pattern of coefficient signs for the two variables reflecting the incentive to over reserve. In addition, we see that *Smooth 2* is negatively related to the size of the under reserving error. That is, the presence of a loss in the previous year reduces the 5 year KFS magnitude of the under reserving error. For the magnitude of the over reserving regression, nothing is significantly related to the size of the over reserving.

It is interesting to note that we see that our measure of the incentive to under reserve is positively related to the size of the under reserve error in Table 8. This is consistent with previous literature, but because the Pre 1993 interaction terms is of the wrong sign it calls into question the inceptive to under reserve for solvency monitoring purposes (Penalva (1998), Peroni, (1993), and Gaver and Patterson (2004). However, if one has a positive error, then the under reserving incentive is irrelevant and what is driving the magnitude of the error is the value of the tax shield.

5.3 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 Wahlen, 2000). Loss reserve errors are categorized as non-discretionary if they "unbiasedly" reflect new information about claims, such as the type of business an insurer writes. Loss reserve errors are classified as discretionary 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.[22]

[22] 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.

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 settlement amount based on the facts of the case when 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 for 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 IBNR/Total Reserve ratio 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:

$$\frac{IBNR\ Reserves}{Total\ Reserves} = h + q Z + x , \qquad (6)$$

where η is the intercept, θ is a vector of coefficients, Z is a vector of explanatory variables and ξ is an error term. For our explanatory variables we use firm size, organizational form, percentage of business in commercial short tail lines, personal long tail lines, and commercial long tail lines; the line of business Herfindahl index, the geographic Herfindahl index, the AM Best Ratings, and year fixed effects.

Second, we obtain an estimate of the deviation from the expected ratio of IBNR to total reserves, which is merely the error term from regression (6). 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 whether a firm's incentives are correlated with the absolute deviation from expectation we estimate the following regression models:

$$
\begin{aligned}
|IBNR\ Dev|^{-} &= a + b\,X + e^{-}\ \ if\ \ IBNR\ Dev < 0 \\
|IBNR\ Dev|^{+} &= a + f\,X + e^{+}\ \ if\ \ IBNR\ Dev > 0
\end{aligned}
\qquad (7)
$$

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), 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 high three-year average return on assets, *Smooth*). If IBNR is the source of a firms' 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 smaller 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 of the deviations from the predicted ratio of IBNR usage ratio are located in Table 9 Panels A (3-Year) and B (5-year). Overall, the value of the tax shield does not impact a firm's under- or over-utilization of IBNR. Thus taxes are not observed to be a strong inducement to alter the proportion of IBNR reserves. The incentive to smooth income, on the other hand, is significantly related to a firm's incentive to deviate from the expected IBNR usage ratio. Our first smoothing measure, *Smooth* suggests that, conditional on a firm having an actual IBNR to total reserve ratio that is less than expected, firms with a relatively higher incentive to smooth income will under use IBNR to a greater extent. This is evidence that firms with higher past performance under reserve for unreported losses in an attempt to smooth inter-temporal income. Our second smoothing incentive measure, *Smooth 2*, shows a greater deviation from the expected proportional of IBNR use given a positive deviation from expectation. This implies that firm's with negative income in the previous year smooth income between periods by over-reserving for unreported losses. In addition, conditional on a lower proportion IBNR than predicted, firm's with a negative income in the previous period smooth income between periods by deviating less from expectation.

We observe revenue efficient firms' absolute deviation is greater if their IBNR usage ratio is less than predicted by the first stage regression and lower if their firms' IBNR usage ratio is greater than expected. Thus, higher ability managers use a smaller proportion of IBNR relative to less experienced managers. This suggests either that relatively better managers utilize greater discretion when it comes to setting IBNR levels or that the opportunity cost of reserving for unreported losses is high for revenue efficient.

With the 5-year measure of the IBNR usage ratio, we witness firm's with a greater percent of total premiums earned in regulated lines in prior approval states deviate less from the expectation. Perhaps these firms are less likely to deviate due to the higher degree of regulatory oversight they face. The on-staff regulatory actuaries, for example, can arguably assess the adequacy of a firm's IBNR usage ratio, therefore firms subject to greater regulatory monitoring are less inclined to use the subjective aspects of the IBNR reserve to meet their firm objectives.

The absolute deviation from the expected proportion of IBNR to total reserves is larger for firms with a higher probability of failure irrespective of whether the firm is above of below the predicted ratio. This is an interesting result. It indicates firms with a relatively high probability of insolvency are more likely to overuse their IBNR, given they have a higher IBNR usage ratio than expected. In contrast, firms 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. On the other hand, the over utilization of IBNR by firms with a relatively high probability of failure suggests that these firms demonstrate an increased conservativeness in reserving for unreported losses to increase firm safety.

Looking at the 5-year estimates of deviation, there is slight evidence insurers' use unreported loss reserves to appear solvent for regulatory purposes. The incentive to under-reserve prior to 1993 (*IUR-Prior to 1993)* is positive for firms with lower than expected proportional use of IBNR and negative for firms with greater than expected IBNR usage. Thus, insurers with a greater incentive to under reserve are less likely to have high IBNR usage ratios prior to 1993, given a higher proportional IBNR usage than predicted. At the same time, the *KFS5* error suggests that firms with a greater incentive to under reserve for solvency regulation purposes use unreported losses to make themselves appear solvent, given that they under-use IBNR compared to the expectation. However, this finding runs counter to the results in the other models. After 1993, the incentive to under reserve for solvency purposes is not discernible. In fact, the direction of our measure for the incentive to under-reserve (*IUR*) is contrary to the IRIS manipulation hypothesis.

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, we examined the incentive to over reserve for insurers using different measures of reserving error. Second, we examined the propensity to be over reserved for a significant period of time. Third, we examined the determinants of the magnitude of loss reserves, and finally we examined the extent the IBNR reserve is the source of reserve error.

We found that the incentive to under reserve (the difference between reported IRIS ratio violations and the IRIS ratio violations which would exist if the reserves had no error) 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. We also found that taxes seem to be a major motivation for over reserving, but they are apparently not related to the use of IBNR reserves. We do find that 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. Finally, we find evidence that firms increase their reserves in strict price regulatory environments to offset price suppression.

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. 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 we, and others, think about smoothing. 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 the future, we plan on employing 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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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								
5. Y_{T-6}	XXXX	XXXX	XXXX				$\mathcal{E}$			$\mathcal{F}$
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.

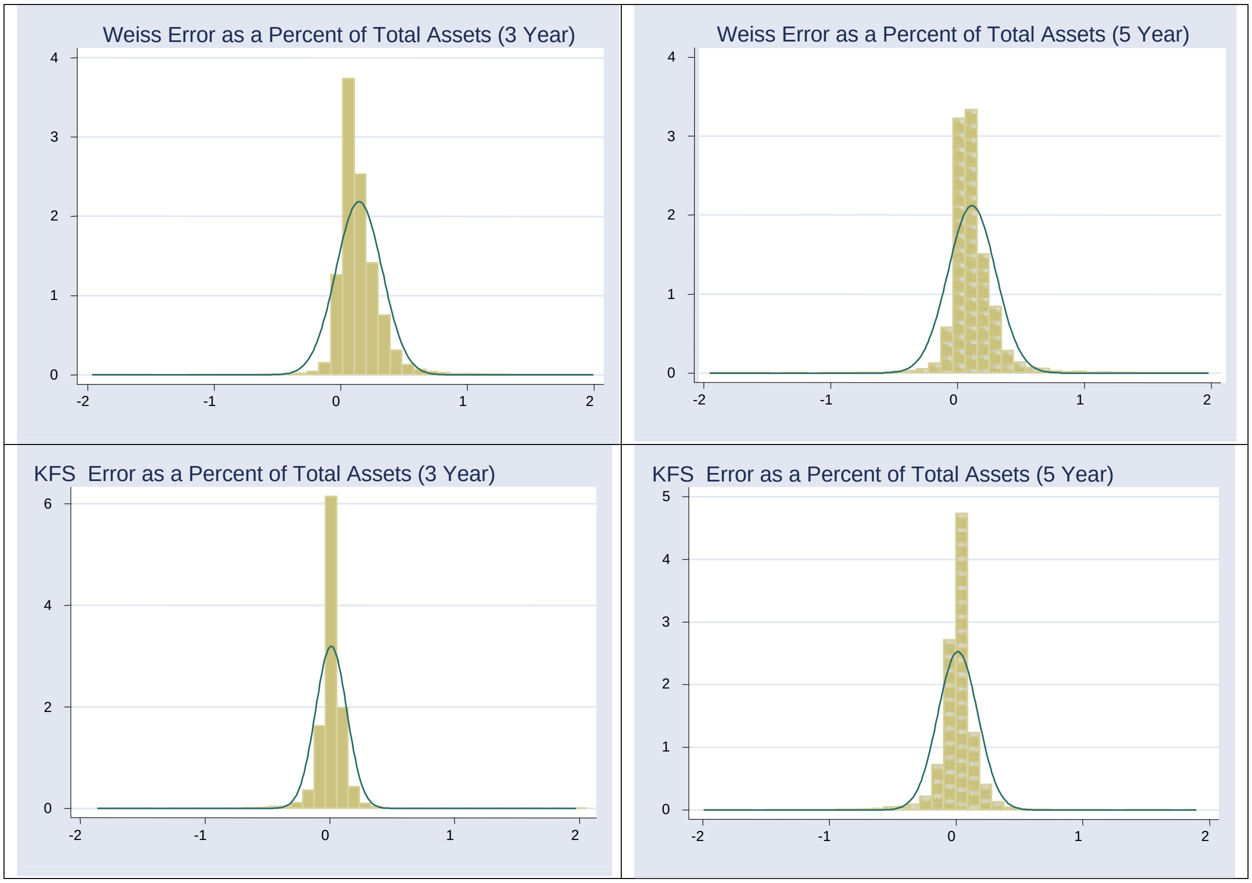
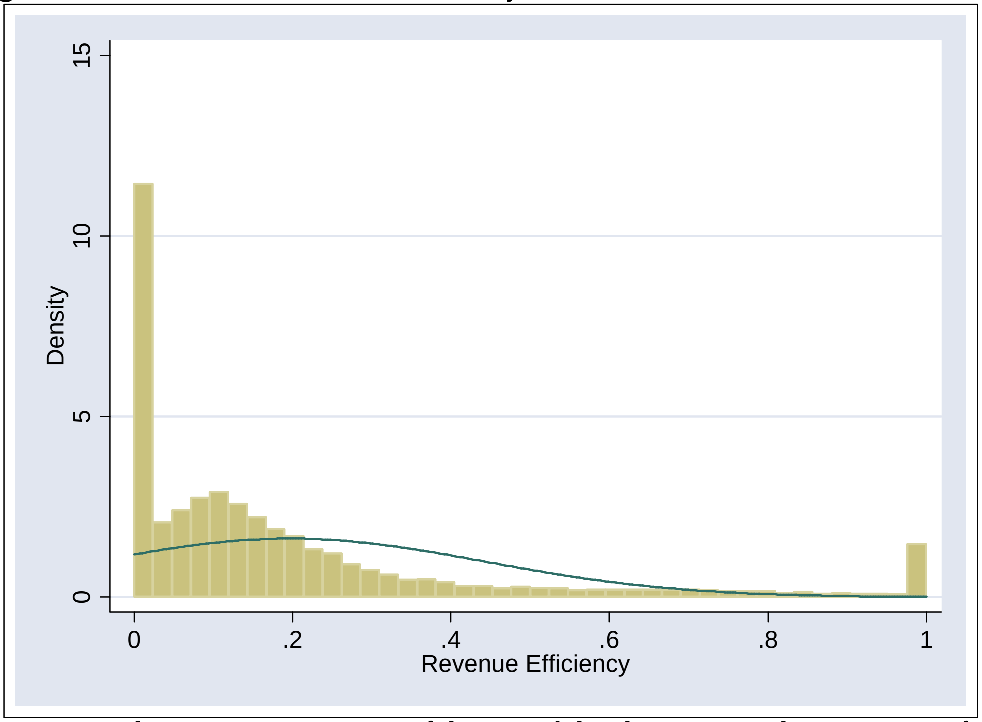


Figure 3. Distribution of Revenue Efficiency from DEA Model of P/C Insures.



Note: Inserted curve is representation of the normal distribution given the parameters of the data.

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

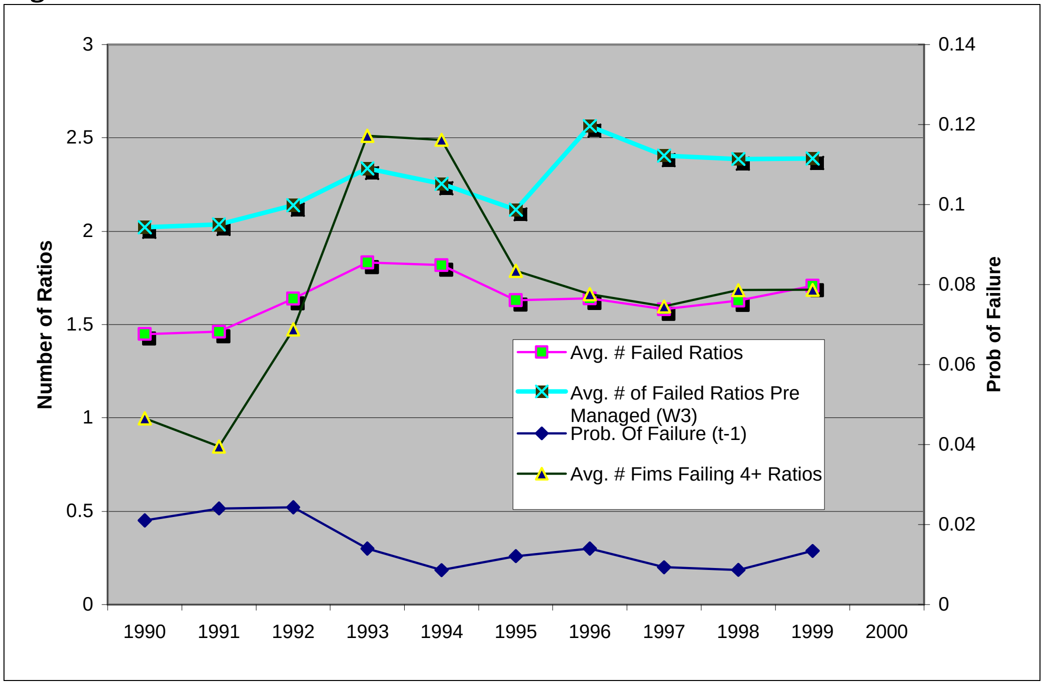
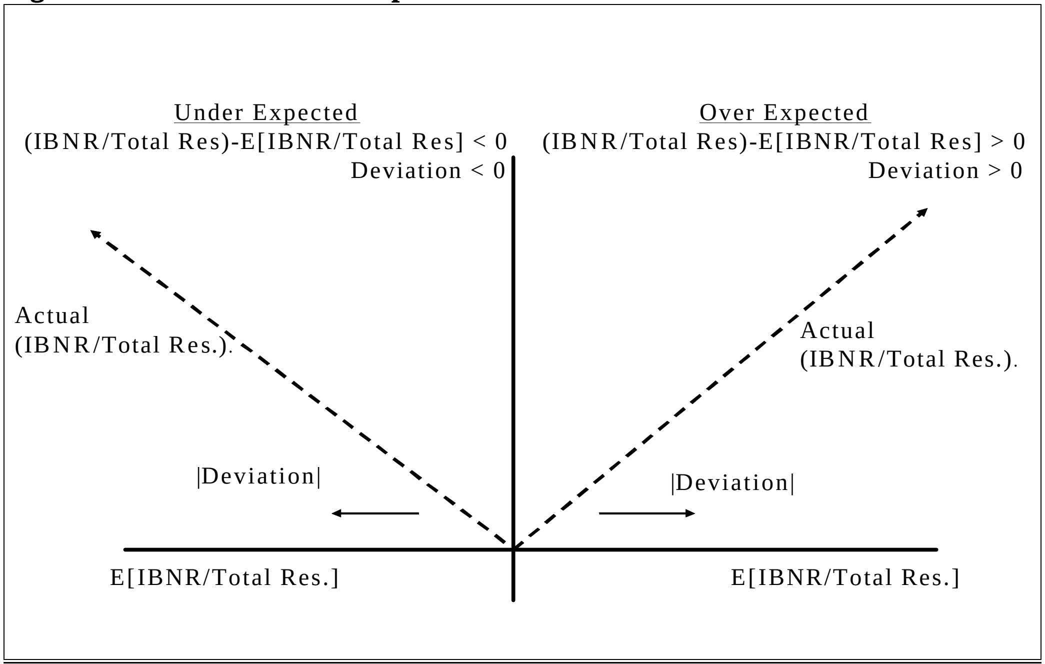


Figure 5: Deviation from the Expected Ratio of IBNR to Total Reserves.



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 $y \to V(y) \subseteq \Re_+^k$. 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:

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

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:

$$\underset{y_s}{Max} \sum_{i=1}^{N} p_{si} y_{si}$$

$$\text{Subject to } Y?_s \geq y_i ,\ i = 1,2,...,N \qquad (4)$$

$$X?_s \leq x_j ,\ j = 1,2,...,M$$

$$\text{and } ?_s \geq 0$$

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.

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
Kazenski 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
Kazenski 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
Kazenski 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
Kazenski 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
Kazenski 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
Kazenski 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
Kazenski 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
Kazenski 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	Gaver-Patterson Error 3 year	Weiss Error 5 Year	Gaver-Patterson Error 5 year
Weiss Error 3 Year	1.000			
Kazenski Error 3 year	0.373	1.000		
Weiss Error 5 Year	0.027	0.013	1.000	
Kazenski 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 Kazanski error is the difference between

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 *t*wo 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 t*he 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 Tax Shield 3 Year (Weiss)	10875	0.168	0.517	0.000	32.116
Value of Tax Shield 3 Year (KFS)	10875	0.055	0.082	0.000	4.036
Value of Tax Shield 5 year (Weiss)	8407	0.147	0.462	0.000	29.731
Value of Tax Shield 5 year (KFS)	8407	0.064	0.114	0.000	5.618
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	3.436	4.950	0.690	0.488	-2.508	2.339	-1.070	0.284
Indicator for Mutual	**0.630**	0.140	4.510	0.000	**0.574**	0.079	7.290	0.000
Indicator for Reciprocal	**0.993**	0.549	1.810	0.071	**0.411**	0.225	1.830	0.067
Indicator for RRG	-				-0.323	1.712	-0.190	0.850
Indicator for Lloyds	-0.191	0.439	-0.440	0.663	**-0.639**	0.315	-2.030	0.043
Indicator for Direct Writer	0.178	0.144	1.240	0.216	**0.369**	0.085	4.360	0.000
Indicator for Member of a Group	**0.420**	0.115	3.650	0.000	0.069	0.079	0.870	0.382
Indicator for Public Stock Company	0.034	0.179	0.190	0.850	**0.253**	0.082	3.100	0.002
Product Mix								
Percent losses incurred in Commercial Short Tail	0.328	0.325	1.010	0.312	**0.143**	0.065	2.210	0.027
Percent losses incurred in Personal Long Tail	**0.607**	0.385	1.580	0.115	**0.450**	0.096	4.680	0.000
Percent losses incurred in Commercial Long Tail	0.172	0.319	0.540	0.591	**-0.492**	0.076	-6.470	0.000
Product Line Herfindahl	0.000	0.001	0.090	0.927	-0.163	0.127	-1.290	0.199
Geographic Herfindahl	0.221	0.157	1.410	0.159	0.137	0.092	1.480	0.138
Efficiency								
Revenue Efficiency	**-0.403**	0.240	-1.680	0.093	-0.140	0.183	-0.770	0.443
Size								
Log of Total Assets	-0.503	0.549	-0.920	0.360	0.106	0.254	0.420	0.678
Log of Total Assets2	0.015	0.015	1.000	0.315	-0.004	0.007	-0.560	0.573
Growth								
Net Premium Written Growth Rate * 100	7.0E-05	6.4E-05	1.090	0.275	5.0E-08	4.9E-07	0.100	0.919
Income & Tax								
Value of Tax Shield 3 Year (Weiss or KFS)	**22.561**	1.102	20.470	0.000	**30.706**	0.882	34.800	0.000
Smooth 2--Indicator for Net Income (t-1) < 0	**0.832**	0.111	7.470	0.000	**0.730**	0.072	10.120	0.000
Smooth -- MA 3 Year (Net Income/Assets)	-0.342	0.519	-0.660	0.510	**-1.080**	0.729	-1.480	0.138
Solvency and Regulation								
Prob of Failure (t-1)	**-7.097**	3.290	-2.160	0.031	-2.712	2.505	-1.080	0.279
Incentive to Under Reserve	**0.507**	0.109	4.650	0.000	**0.188**	0.067	2.790	0.005
Incentive to Under Reserve Prior to 1993	-0.075	0.122	-0.620	0.537	-0.066	0.079	-0.840	0.400
Pct Prems Earned in Regulated Lines in Prior Approva	**0.519**	0.179	2.900	0.004	**0.255**	0.106	2.400	0.017
Best Rating: C++ or C+	-0.477	0.378	-1.260	0.206	-0.280	0.330	-0.850	0.395
Best Rating: B or B-	**-0.806**	0.194	-4.150	0.000	-0.229	0.156	-1.470	0.142
Best Rating: B+ or B++	-0.147	0.166	-0.890	0.376	0.096	0.131	0.740	0.462
Best Rating: A or A-	**0.392**	0.159	2.460	0.014	**0.342**	0.123	2.790	0.005
Best Rating: A+ or A++	**0.501**	0.193	2.600	0.009	**0.385**	0.133	2.890	0.004

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

	Model 1	Model 2
Log Likelihood	-1616	-4216
N	8709	8704
Pseudo R^2	0.347	0.257

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	4.976	5.778	0.860	0.389	**-13.835**	3.412	-4.050	0.000
Indicator for Mutual	**0.444**	0.147	3.020	0.003	**0.770**	0.105	7.310	0.000
Indicator for Reciprocal	**1.046**	0.574	1.820	0.068	**0.997**	0.330	3.020	0.003
Indicator for RRG	-1.873	1.290	-1.450	0.147	**-2.107**	1.321	-1.600	0.111
Indicator for Lloyds	0.450	0.670	0.670	0.502	-0.318	0.428	-0.740	0.458
Indicator for Direct Writer	**0.311**	0.156	2.000	0.046	**0.197**	0.110	1.800	0.072
Indicator for Member of a Group	**0.207**	0.126	1.650	0.100	**-0.164**	0.107	-1.530	0.125
Indicator for Public Stock Company	-0.307	0.184	-1.670	0.094	**0.527**	0.115	4.590	0.000
Product Mix								
Percent losses incurred in Commercial Short Tail	-0.013	0.268	-0.050	0.960	0.098	0.116	0.840	0.398
Percent losses incurred in Personal Long Tail	**0.334**	0.337	0.990	0.322	**0.827**	0.182	4.560	0.000
Percent losses incurred in Commercial Long Tail	0.143	0.268	0.530	0.594	**-0.276**	0.138	-2.000	0.045
Product Line Herfindahl	0.000	0.001	0.060	0.956	0.000	0.001	0.060	0.956
Geographic Herfindahl	**0.502**	0.163	3.080	0.002	**0.500**	0.121	4.120	0.000
Efficiency								
Revenue Efficiency	-0.228	0.311	-0.740	0.462	-0.348	0.261	-1.330	0.182
Size								
Log of Total Assets	-0.829	0.628	-1.320	0.187	**1.172**	0.356	3.290	0.001
Log of Total Assets2	**0.025**	0.017	1.490	0.135	**-0.029**	0.009	-3.140	0.002
Growth								
Net Premium Written Growth Rate * 100	0.000	0.000	0.070	0.948	0.000	0.000	-0.660	0.507
Income & Tax								
Value of Tax Shield 5 Year (Weiss or KFS)	**22.609**	1.190	19.000	0.000	**34.457**	1.127	30.580	0.000
Smooth 2--Indicator for Net Income (t-1) < 0	**0.994**	0.129	7.680	0.000	**0.980**	0.096	10.230	0.000
Smooth -- MA 3 Year (Net Income/Assets)	**-6.454**	1.360	-4.740	0.000	**-4.071**	1.104	-3.690	0.000
Solvency and Regulation								
Prob of Failure (t-1)	-0.281	4.474	-0.060	0.950	3.717	3.010	1.230	0.217
Pct Prems Earned in Regulated Lines in Prior Approva	**0.547**	0.202	2.700	0.007	**0.393**	0.147	2.680	0.007
Incentive to Under Reserve	**0.175**	0.055	3.200	0.001	-0.066	0.072	-0.910	0.360
Incentive to Under Reserve Prior to 1993	**0.272**	0.058	4.690	0.000	0.049	0.088	0.560	0.575
Best Rating: C++ or C+	-0.539	0.453	-1.190	0.235	**-0.848**	0.509	-1.660	0.096
Best Rating: B or B-	**-0.518**	0.243	-2.130	0.033	-0.098	0.225	-0.440	0.663
Best Rating: B+ or B++	-0.043	0.197	-0.220	0.829	0.248	0.186	1.340	0.181
Best Rating: A or A-	**0.802**	0.189	4.250	0.000	**0.446**	0.172	2.590	0.009
Best Rating: A+ or A++	**1.276**	0.225	5.680	0.000	**0.533**	0.186	2.860	0.004

	Model 1	Model 2
Log-Likelihood	-3195	-2280
N	5628	5625
Pseudo R^2	0.1256	0.376

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	11.601	-26.677	-10.585	-20.202
	(3.231) ***	(11.153) **	(2.243) ***	(3.951) ***
Indicator for Mutual	0.395	0.231	0.745	0.352
	(0.080) ***	(0.210)	(0.074) ***	(0.108) ***
Indicator for RRG	2.194	--	-2.227	0.067
	(1.145) *		(0.800) ***	(1.049)
Indicator for Lloyds	-0.238	0.418	--	--
	(0.314)	(0.659)		
Indicator for Reciprocal	1.775	-1.394	0.672	0.880
	(0.320) ***	(1.033)	(0.202) ***	(0.224) ***
Indicator for Direct Writer	0.180	0.225	0.747	0.285
	(0.082) **	(0.199)	(0.079) ***	(0.099) ***
Indicator for Member of a Group	0.344	0.388	-0.156	-0.234
	(0.073) ***	(0.177) **	(0.073) **	(0.103) **
Indicator for Public Stock Company	0.233		0.617	0.628
	(0.091) **		(0.075) ***	(0.098) ***
Product Mix				
Percent losses incurred in Commercial Short Tail	-0.194	-0.798	0.256	-0.018
	(0.063) ***	(0.543)	(0.077) ***	(0.101)
Percent losses incurred in Commercial Long Tail	0.339	-1.305	-0.486	0.046
	(0.077) ***	(0.528) **	(0.094) ***	(0.086)
Percent losses incurred in Personal Long Tail	-0.069	-2.415	0.941	0.791
	(0.097)	(0.654) ***	(0.132) ***	(0.162)
Product Line Herfindahl	0.000	0.000	0.455	-0.017
	(0.000)	(0.001)	(0.119) ***	(0.176)
Geographic Herfindahl	0.478	-0.203	-0.058	0.334
	(0.093) ***	(0.233)	(0.085)	(0.115) ***
Efficiency				
Revenue Efficiency	-0.411	0.858	-0.758	0.293
	(0.170) **	(0.385) **	(0.169) ***	(0.265)
Size				
Log of Total Assets	-1.728	3.498	1.052	1.746
	(0.355) ***	(1.255) ***	(0.238) ***	(0.410) ***
Log of Total Assets2	0.054	-0.112	-0.031	-0.046
	(0.010) ***	(0.035) ***	(0.006) ***	(0.011) ***
Growth				
Net Premium Written Growth Rate * 100	-6.78E-07	-3.29E-04	1.83E-07	-1.95E-04
	(8.90E-07)	(4.35E-04)	(5.44E-07)	(9.81E-05) **
Tax and Income				
Value of Tax Shield 3 Year (Weiss)	7.474	-9.408	17.001	12.864
	(0.369) ***	(1.294) ***	(0.633) **	(0.644) ***
Smooth 2--Indicator for Net Income (t-1) < 0	0.286	-0.475	0.423	0.377
	(0.075) ***	(0.190) **	(0.070) ***	(0.116) ***
Smooth -- MA 3 Year (Net Income/Assets)	1.226	0.159	4.024	5.460
	(0.651) *	(1.730)	(0.734) ***	(1.112) ***
Solvency				
Prob of Failure (t-1)	-4.931	-4.907	-2.353	-5.408
	(2.299) **	(7.048)	(2.267)	(5.103)
Best Rating: C++ or C+	-0.272	-0.757	--	--
	(0.365)	(0.662)		
Best Rating: B or B-	-0.420	-1.423	-0.088	0.018
	(0.162) ***	(0.399) ***	(0.154)	(0.334)
Best Rating: B+ or B++	0.255	-0.749	0.239	0.196
	(0.123) **	(0.255) ***	(0.123) *	(0.248)
Best Rating: A or A-	0.863	-0.830	0.458	1.056
	(0.115) ***	(0.234) ***	(0.117) ***	(0.227) ***
Best Rating: A+ or A++	0.999	-0.848	0.719	1.531
	(0.128) ***	(0.286) ***	(0.127) ***	(0.236) ***
Incentive to Under Reserve	0.326	-0.158	0.126	0.333
	(0.048) ***	(0.080) **	(0.061) **	(0.064) ***
Incentive to Under Reserve Prior to 1993	-0.151	0.091	-0.094	-0.353
	(0.053) ***	(0.076)	(0.070)	(0.075) ***
Pct Prems Earned in Regulated Lines in Prior Approv	0.791	-0.871	0.106	0.014
	(0.105) ***	(0.318) ***	(0.098)	(0.137)
N	8719	5622	8719	5568
Psuedo-R^2	0.243	0.191	0.188	0.221
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	0.355	0.715	0.500	0.620	0.054	0.312	0.170	0.862
Indicator for Mutual	**0.040**	0.018	2.160	0.031	0.001	0.009	0.060	0.951
Indicator for Reciprocal	-0.028	0.082	-0.350	0.727	-0.013	0.023	-0.570	0.571
Indicator for RRG					0.000	0.081	0.000	1.000
Indicator for Lloyds	-0.011	0.053	-0.200	0.839	-0.029	0.041	-0.720	0.469
Indicator for Direct Writer	-0.033	0.021	-1.610	0.108	-0.012	0.010	-1.170	0.242
Indicator for Member of a Group	0.014	0.016	0.910	0.363	-0.001	0.010	-0.110	0.912
Indicator for Public Stock Company	-0.038	0.025	-1.500	0.133	-0.012	0.009	-1.340	0.179
Product Mix								
Percent losses incurred in Commercial Short Tail	0.059	0.045	1.290	0.197	-0.001	0.005	-0.230	0.818
Percent losses incurred in Personal Long Tail	0.032	0.053	0.600	0.549	-0.011	0.009	-1.180	0.238
Percent losses incurred in Commercial Long Tail	0.069	0.044	1.570	0.116	0.006	0.005	1.070	0.284
Product Line Herfindahl	**0.084**	0.028	2.980	0.003	0.000	0.000	0.620	0.538
Geographic Herfindahl	0.007	0.022	0.300	0.762	-0.004	0.012	-0.350	0.724
Efficiency								
Revenue Efficiency	0.042	0.027	1.550	0.122	0.014	0.017	0.790	0.429
Size								
Log of Total Assets	-0.054	0.081	-0.670	0.501	-0.006	0.033	-0.170	0.863
Log of Total Assets2	0.002	0.002	0.840	0.399	0.000	0.001	0.180	0.859
Growth								
Net Premium Written Growth Rate * 100	0.000	0.000	-0.050	0.958	0.000	0.000	-0.210	0.837
Income & Tax								
Value of Tax Shield 3 Year	-0.016	0.108	-0.150	0.881	**0.897**	0.007	129.620	0.000
Smooth -- MA 3 Year (Net Income/Assets)	**-0.242**	0.135	-1.790	0.074	-0.050	0.052	-0.970	0.331
Smooth 2--Indicator for Net Income (t-1) < 0	0.012	0.012	1.060	0.291	**0.062**	0.007	9.010	0.000
Solvency and Regulation								
Prob of Failure (t-1)	0.181	0.334	0.540	0.588	0.351	0.241	1.460	0.145
Pct Prems Earned in Regulated Lines in Prior Approval State	0.031	0.024	1.280	0.200	0.011	0.013	0.850	0.397
Incentive to Under Reserve	**0.075**	0.014	5.320	0.000	-0.006	0.004	-1.580	0.114
Incentive to Under Reserve Prior to 1993	-0.024	0.015	-1.570	0.117	0.006	0.004	1.480	0.139
Best Rating: C++ or C+	**-0.054**	0.041	-1.300	0.194	-0.007	0.044	-0.160	0.872
Best Rating: B or B-	**-0.052**	0.021	-2.410	0.016	-0.012	0.021	-0.560	0.577
Best Rating: B+ or B++	**-0.056**	0.020	-2.860	0.004	-0.013	0.016	-0.840	0.401
Best Rating: A or A-	**-0.065**	0.020	-3.280	0.001	-0.009	0.014	-0.630	0.530
Best Rating: A+ or A++	**-0.055**	0.026	-2.110	0.035	-0.018	0.016	-1.150	0.249
Year Indicators Omitted								
r	0.559				0.4151			
N	715				8003			
R^2	0.181				0.702			

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	-1.172	1.464	-0.800	0.423	0.079	0.066	1.210	0.228
Indicator for Mutual	-0.014	0.046	-0.300	0.762	0.001	0.002	0.730	0.465
Indicator for Reciprocal	-0.009	0.143	-0.060	0.951	0.004	0.005	0.910	0.361
Indicator for RRG	-0.098	0.755	-0.130	0.896	**0.059**	0.016	3.670	0.000
Indicator for Lloyds	-0.006	0.161	-0.040	0.972	**-0.018**	0.009	-1.970	0.049
Indicator for Direct Writer	-0.011	0.055	-0.190	0.848	-0.001	0.002	-0.330	0.741
Indicator for Member of a Group	0.022	0.048	0.470	0.640	**-0.004**	0.002	-1.900	0.058
Indicator for Public Stock Company	-0.017	0.045	-0.380	0.706	**-0.004**	0.002	-2.220	0.026
Product Mix								
Percent losses incurred in Commercial Short Tail	0.022	0.018	1.210	0.225	0.000	0.002	0.250	0.799
Percent losses incurred in Personal Long Tail	-0.055	0.035	-1.580	0.115	**-0.010**	0.003	-3.200	0.001
Percent losses incurred in Commercial Long Tail	-0.002	0.018	-0.090	0.932	0.001	0.002	0.660	0.507
Product Line Herfindahl	0.000	0.000	-0.340	0.732	**0.012**	0.003	3.680	0.000
Geographic Herfindahl	-0.060	0.057	-1.060	0.291	**0.007**	0.002	2.740	0.006
Efficiency								
Revenue Efficiency	0.101	0.079	1.280	0.201	0.002	0.004	0.630	0.531
Size								
Log of Total Assets	0.169	0.156	1.090	0.277	-0.005	0.007	-0.660	0.510
Log of Total Assets2	-0.005	0.004	-1.290	0.198	0.000	0.000	0.560	0.573
Growth								
Net Premium Written Growth Rate * 100	0.000	0.000	-0.090	0.926	0.000	0.000	-0.020	0.981
Income & Tax								
Value of Tax Shield 3 Year (Weiss)	-0.261	0.290	-0.900	0.369	**0.306**	0.010	30.240	0.000
Smooth -- MA 3 Year (Net Income/Assets)	-0.285	0.410	-0.700	0.487	-0.013	0.010	-1.310	0.191
Smooth 2--Indicator for Net Income (t-1) < 0	-0.043	0.029	-1.470	0.142	**0.014**	0.002	7.840	0.000
Solvency and Regulation								
Prob of Failure (t-1)	-0.781	1.033	-0.760	0.450	**0.106**	0.054	1.960	0.050
Pct Prems Earned in Regulated Lines in Prior Appro	0.037	0.064	0.570	0.566	0.004	0.003	1.470	0.141
Incentive to Under Reserve	0.035	0.028	1.250	0.210	**0.021**	0.001	16.720	0.000
Incentive to Under Reserve Prior to 1993	0.019	0.032	0.570	0.568	-0.001	0.001	-0.750	0.451
Best Rating: C++ or C+	-0.023	0.149	-0.150	0.880	**-0.020**	0.011	-1.860	0.063
Best Rating: B or B-	-0.043	0.080	-0.540	0.591	**-0.018**	0.005	-4.050	0.000
Best Rating: B+ or B++	-0.036	0.066	-0.540	0.588	**-0.020**	0.003	-5.930	0.000
Best Rating: A or A-	-0.054	0.064	-0.840	0.401	**-0.021**	0.003	-6.480	0.000
Best Rating: A+ or A++	-0.052	0.072	-0.720	0.469	**-0.024**	0.003	-6.860	0.000
Year Indicators Omitted								
r	0.5699				0.36			
N	3108				5596			
R^2	0.010				0.340			

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	2.222	1.378	1.610	0.107	**9.556**	5.320	1.800	0.073
Indicator for Mutual	0.012	0.017	0.670	0.506	-0.118	0.160	-0.740	0.461
Indicator for Reciprocal	-0.001	0.057	-0.020	0.984	-0.056	0.370	-0.150	0.879
Indicator for RRG					-0.241	2.002	-0.120	0.904
Indicator for Lloyds	-0.043	0.164	-0.260	0.795	-0.283	0.682	-0.410	0.678
Indicator for Direct Writer	0.010	0.037	0.280	0.779	0.006	0.152	0.040	0.967
Indicator for Member of a Group	0.012	0.021	0.590	0.556	0.154	0.157	0.980	0.326
Indicator for Public Stock Company	-0.010	0.021	-0.500	0.617	-0.137	0.158	-0.870	0.386
Product Mix								
Percent losses incurred in Commercial Short Tail	0.011	0.052	0.210	0.835	-0.177	0.182	-0.970	0.332
Percent losses incurred in Personal Long Tail	-0.065	0.062	-1.060	0.289	0.062	0.252	0.250	0.805
Percent losses incurred in Commercial Long Tail	-0.036	0.049	-0.750	0.455	0.076	0.114	0.670	0.504
Product Line Herfindahl	-0.023	0.021	-1.090	0.277	0.000	0.000	-0.020	0.980
Geographic Herfindahl	**-0.058**	0.036	-1.630	0.104	-0.007	0.176	-0.040	0.967
Efficiency								
Revenue Efficiency	0.040	0.028	1.450	0.148	-0.407	0.430	-0.950	0.344
Size								
Log of Total Assets	-0.213	0.152	-1.400	0.162	**-0.935**	0.551	-1.700	0.090
Log of Total Assets2	0.005	0.004	1.290	0.198	0.022	0.014	1.580	0.115
Growth								
Net Premium Written Growth Rate * 100	0.000	0.000	-0.300	0.765	0.000	0.000	0.090	0.929
Income & Tax								
Value of Tax Shield 5 Year	-0.007	0.040	-0.170	0.866	**1.075**	0.213	5.030	0.000
Smooth -- MA 3 Year (Net Income/Assets)	-0.014	0.184	-0.080	0.939	-0.265	1.576	-0.170	0.866
Smooth 2--Indicator for Net Income (t-1) < 0	0.018	0.009	2.050	0.041	-0.059	0.177	-0.330	0.738
Solvency and Regulation								
Prob of Failure (t-1)	-0.015	0.414	-0.040	0.971	-2.574	5.577	-0.460	0.644
Pct Prems Earned in Regulated Lines in Prior Appro	0.014	0.032	0.440	0.658	-0.038	0.213	-0.180	0.860
Incentive to Under Reserve	**0.034**	0.005	6.370	0.000	-0.010	0.050	-0.210	0.835
Incentive to Under Reserve Prior to 1993	**-0.018**	0.005	-3.480	0.001	0.034	0.051	0.670	0.505
Best Rating: C++ or C+	-0.108	0.065	-1.640	0.101	-0.049	1.146	-0.040	0.966
Best Rating: B or B-	**-0.040**	0.023	-1.720	0.086	-0.050	0.425	-0.120	0.907
Best Rating: B+ or B++	-0.030	0.023	-1.310	0.190	-0.030	0.326	-0.090	0.927
Best Rating: A or A-	**-0.046**	0.026	-1.760	0.080	0.118	0.301	0.390	0.695
Best Rating: A+ or A++	**-0.061**	0.033	-1.870	0.062	0.020	0.318	0.060	0.950
Year Indicators Omitted								
r	0.937				-0.2507			
N	661				4967			
R^2	0.1268				0.009			

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	-5.099	3.495	-1.460	0.145	**12.941**	6.098	2.120	0.034
Indicator for Mutual	-0.036	0.093	-0.380	0.702	-0.215	0.178	-1.200	0.228
Indicator for Reciprocal	0.043	0.326	0.130	0.896	-0.080	0.374	-0.210	0.831
Indicator for RRG	-0.214	1.238	-0.170	0.863	-0.154	3.363	-0.050	0.964
Indicator for Lloyds	-0.043	0.363	-0.120	0.906	-0.349	0.774	-0.450	0.652
Indicator for Direct Writer	0.023	0.117	0.200	0.845	0.016	0.160	0.100	0.919
Indicator for Member of a Group	0.086	0.102	0.850	0.398	0.193	0.165	1.170	0.243
Indicator for Public Stock Company	0.017	0.098	0.170	0.864	-0.198	0.165	-1.210	0.228
Product Mix								
Percent losses incurred in Commercial Short Tail	-0.088	0.135	-0.660	0.512	-0.169	0.191	-0.880	0.377
Percent losses incurred in Personal Long Tail	-0.154	0.139	-1.110	0.268	0.263	0.303	0.870	0.386
Percent losses incurred in Commercial Long Tail	0.000	0.031	0.010	0.991	0.182	0.240	0.760	0.448
Product Line Herfindahl	-0.027	0.118	-0.230	0.819	0.000	0.000	-0.050	0.957
Geographic Herfindahl	**-0.230**	0.124	-1.850	0.064	-0.057	0.189	-0.300	0.765
Efficiency								
Revenue Efficiency	0.178	0.184	0.970	0.333	-0.438	0.518	-0.850	0.398
Size								
Log of Total Assets	**0.663**	0.367	1.810	0.071	**-1.248**	0.627	-1.990	0.047
Log of Total Assets2	**-0.020**	0.010	-2.130	0.034	**0.029**	0.016	1.830	0.067
Growth								
Net Premium Written Growth Rate * 100	0.000	0.000	-0.040	0.966	0.000	0.000	-0.150	0.884
Income & Tax								
Value of Tax Shield 3 Year (Weiss)	-0.075	0.215	-0.350	0.728	-0.559	0.985	-0.570	0.570
Smooth -- MA 3 Year (Net Income/Assets)	-0.969	0.966	-1.000	0.316	0.364	1.755	0.210	0.836
Smooth 2--Indicator for Net Income (t-1) < 0	**-0.121**	0.054	-2.220	0.026	-0.311	0.233	-1.340	0.181
Solvency and Regulation								
Prob of Failure (t-1)	-1.020	2.222	-0.460	0.646	-5.911	8.280	-0.710	0.475
Pct Prems Earned in Regulated Lines in Prior Appr	0.193	0.141	1.360	0.173	-0.050	0.224	-0.220	0.823
Incentive to Under Reserve	**0.101**	0.042	2.390	0.017	0.044	0.123	0.360	0.717
Incentive to Under Reserve Prior to 1993	**-0.011**	0.051	-0.220	0.825	0.017	0.142	0.120	0.907
Best Rating: C++ or C+	-0.065	0.277	-0.240	0.814	0.089	2.231	0.040	0.968
Best Rating: B or B-	-0.065	0.172	-0.380	0.706	-0.067	0.491	-0.140	0.892
Best Rating: B+ or B++	0.048	0.140	0.340	0.732	0.015	0.385	0.040	0.969
Best Rating: A or A-	-0.059	0.135	-0.430	0.665	0.152	0.360	0.420	0.674
Best Rating: A+ or A++	-0.054	0.152	-0.360	0.721	0.058	0.377	0.150	0.878
Year Indicators Omitted								
r	0.6823				-0.742			
N	1988				3638			
R^2	0.030				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	0.024	0.031	0.023	0.030
	(0.003) ***	(0.004) ***	(0.003) ***	(0.004) ***
Tax				
Value of Tax Shield 3 Year (Weiss)	-0.001	0.004	-0.003	0.027
	(0.005)	(0.004)	(0.009)	(0.031)
Smooth 2--Indicator for Net Income (t-1) < 0	-0.003	0.009	-0.003	0.011
	(0.001) **	(0.005) **	(0.001) **	(0.005) **
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)	0.092	0.047	0.094	0.043
	(0.023) ***	(0.028) *	(0.023) ***	(0.028)
Efficiency				
Revenue Efficiency	0.019	-0.036	0.020	-0.036
	(0.003) ***	(0.010) ***	(0.003) ***	(0.010) ***
Regulation				
Prob of Failure (t-1)	0.156	0.278	0.161	0.236
	(0.043) ***	(0.137) **	(0.043) ***	(0.136) *
Pct Prems Earned in Regulated Lines in Prior Approval State	-0.001	-0.008	-0.001	-0.007
	(0.005)	(0.007)	(0.005)	(0.007)
Difference Between Total Reported Failed Ratios and Failed Managed Ratios	0.000	-0.003	0.001	0.002
	(0.001)	(0.003)	(0.001)	(0.004)
Difference Between Number of Failed Ratios * Prior to 1993	-0.001	0.003	-0.002	-0.001
	(0.001) **	(0.003)	(0.001) **	(0.004)
Indicator for Public Stock Company	-0.001	-0.011	-0.001	-0.010
	(0.002)	(0.006) *	(0.002)	(0.006) *
Rho	0.982	0.264	0.981	0.264
N	4236	4443	4236	4435
R^2	0.03	0.65	0.03	0.65
Panel B. Five Year Period	**W Error 5 Year**		**KFS Error 5 Year**	
Variable Name				
Intercept	0.042	0.038	0.040	0.036
	(0.003) ***	(0.002) ***	(0.003) ***	(0.002) ***
Tax				
Value of Tax Shield 3 Year	0.000	0.003	0.002	0.017
	(0.005)	(0.003)	(0.006)	(0.011)
Smooth 2--Indicator for Net Income (t-1) < 0	0.003	0.005	0.004	0.007
	(0.003)	(0.002) **	(0.003)	(0.002) ***
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)	0.075	0.005	0.077	-0.001
	(0.028) ***	(0.024)	(0.028) ***	(0.024)
Efficiency				
Revenue Efficiency	0.019	-0.036	0.020	-0.036
	(0.003) ***	(0.010) ***	(0.003) ***	(0.010) ***
Regulation				
Prob of Failure (t-1)	0.224	0.391	0.276	0.371
	(0.103) **	(0.058) ***	(0.106) ***	(0.059) ***
Pct Prems Earned in Regulated Lines in Prior Approval State	-0.035	-0.012	-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	0.006	-0.008
	(0.001)	(0.001) ***	(0.003) **	(0.001) ***
Indicator for Public Stock Company	0.002	0.003	0.001	0.003
	(0.004)	(0.003)	(0.003)	(0.003)
Rho	0.028	0.097	0.697	0.388
N	2235	3296	2235	3297
R^2	0.698	0.389	0.028	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								
5. Y_{T-6}	XXXX	XXXX	XXXX				$\mathcal{E}$			$\mathcal{F}$
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

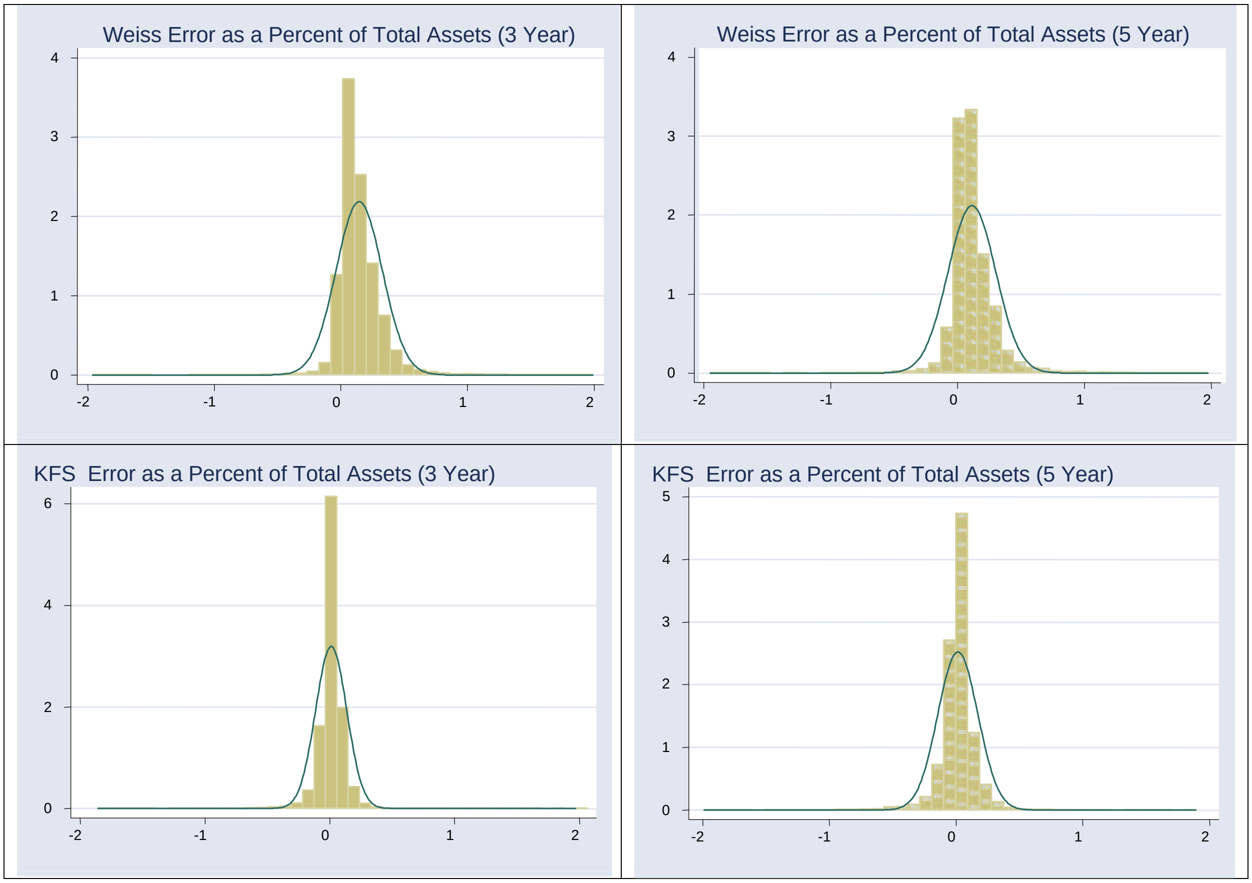


Figure 3. Distribution of Revenue Efficiency from DEA Model of P/C Insures.

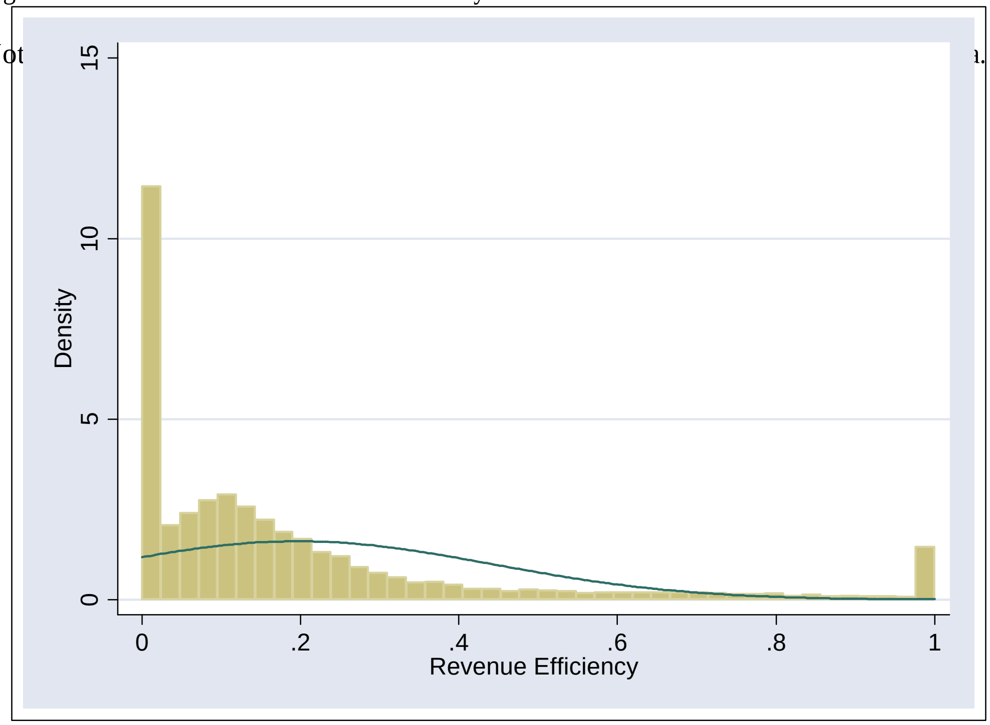


Figure 4. Indicators of Financial Weakness over 1990-1999.

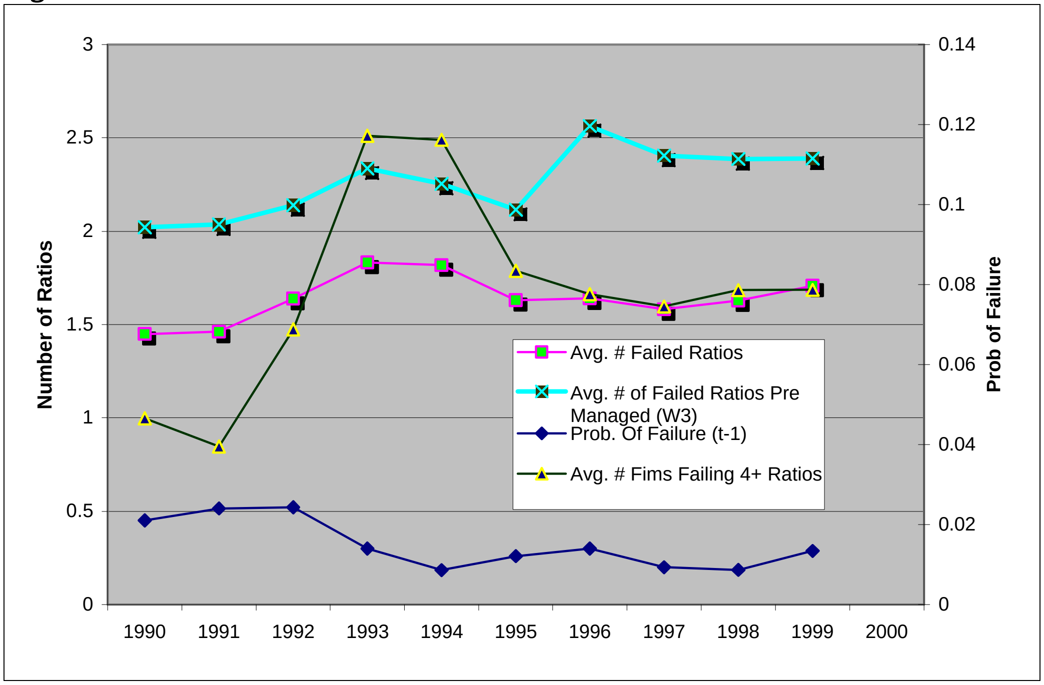
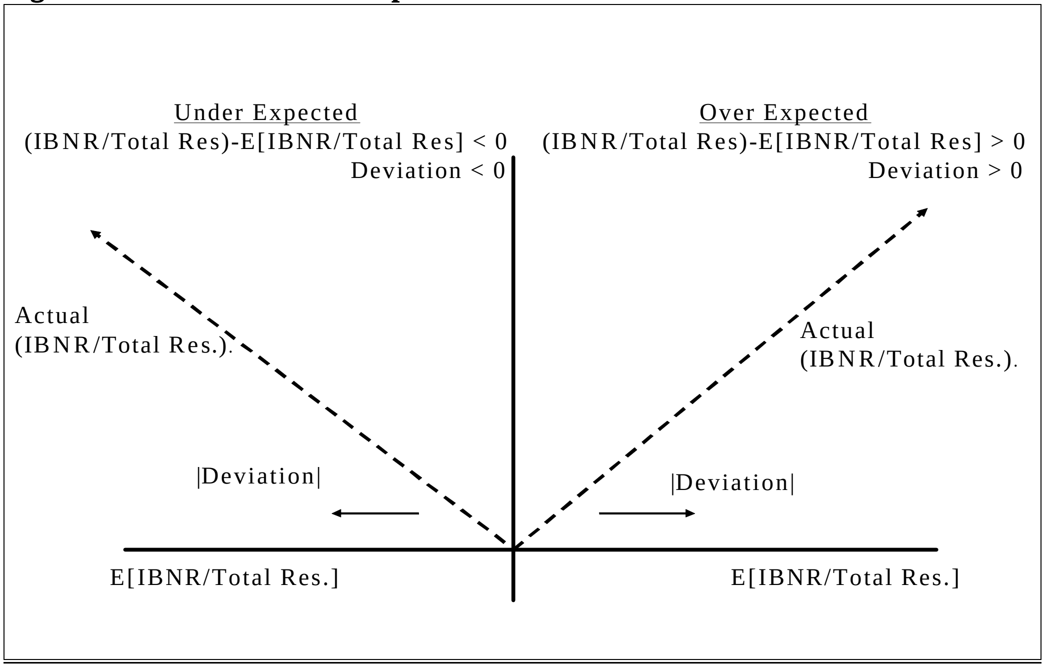


Figure 5: Deviation from the Expected Ratio of IBNR to Total Reserves.



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 $y \to V(y) \subseteq \Re_+^k$. 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:

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

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:

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

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**
	Price =(Premiums Earned - PV(LI)) / PV(LI)
Present Value of Real Losses Incurred	
-personal short-tail lines	
-personal long-tail lines	
-commercial short-tail lines	
-commercial long-tail lines	
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