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Reinsurance Purchases, Contingent Commission Payments and Insurer Reserve Estimation

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Prior studies on errors in reserve estimation suggest that insurers manage loss reserves to achieve corporate goals, including tax minimisation and income smoothing. Analysing U.S. property and casualty insurance industry data, we find a relationship between reserve errors and the purchase of reinsurance. A relationship is also found between reserve errors and the payment of contingent commissions. Since reserve errors may be costly in both instances, insurers who purchase reinsurance and those who pay contingent commissions may have a greater incentive to reserve accurately than other insurers. We find that in these cases insurers report smaller over-reserving errors.
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Introduction

Optimal transfer of risk through financial markets requires contracting based on openness and honesty. Asymmetries in information between parties (for instance, ceding companies and reinsurance companies) have the potential of leading to a suboptimal transfer of risk in the market.[1] In extreme cases, market collapse is possible.

A growing body of research suggests that insurers manage reserve levels to achieve corporate objectives. These objectives may include, among others, minimisation of taxes, smoothing of earnings and avoidance of regulatory scrutiny. While the putative benefits of reserve management have received considerable scholarly attention, the potential costs have received less.[2]

[1] See, for instance, Akerlof (1970) and Rothschild and Stiglitz (1976).

[2] The accuracy of reserving estimates is revealed over time as actual loss experience develops. Until loss experience is fully developed, there is room for insurers to either over or under estimate reserves to pursue corporate objectives. We refer to this practice as "reserve management". Reserve management has the potential to deceive ill-informed third parties, including reinsurers, brokers, agents and investors.

Through reserve management, insurers can attempt to mislead taxing authorities, financial markets and regulators. Inaccuracies in reserve estimation upon discovery may be damaging to relationships with affected parties, including reinsurers, brokers, and agents who are paid contingent commissions and investors. To the degree third parties are unable to differentiate between insurers that manage reserves and those that do not, the accuracy of all becomes suspect. Depending on whom the third party is, this can lead to enhanced regulatory scrutiny, tax audits or lower prices on securities, such as debt instruments and equity. As such, it is reasonable to expect that, other things equal, an insurer with a history of reporting reserves accurately would be able to enter into more favourable contracts with business partners and enhance its market value by sending a credible signal to the financial markets that it is not engaged in reserve management.[3] The current study tests whether insurers who purchase reinsurance and insurers who pay contingent commissions to agents and brokers report more accurate reserves than other insurers.

Research on reinsurance has not previously considered its association with reserving errors. The role of reinsurance in optimally allocating risk has received attention from scholars. Research has also considered incentives that arise from the purchase of reinsurance. Borch[4] demonstrates that reinsurance can lead to optimal risk-sharing in a society composed of risk-averse agents. Mayers and Smith[5] emphasise the role that reinsurance plays in allowing primary insurers to hedge the risks they have assumed. They report that primary insurers with less concentrated books of business exhibit a greater demand for reinsurance than more focused insurers. Consistent with Mayers and Smith,[5] Garven and Lamm-Tennant[6] state that reinsurance reduces both the variability of cash flows of a primary insurer and its financial leverage. The decision to purchase reinsurance, therefore, has both risk management and financial management implications. Their work finds that reinsurance demand is positively correlated with the cedent's degree of leverage and its writings of long-tailed lines of coverage. In addition, they find demand to be negatively correlated with a primary insurer's investment returns and claims costs.

Prior research has also highlighted the potential for moral hazard that arises with reinsurance.[7] Similar to moral hazard in the primary insurance market, with reinsurance the transfer of risk reduces the incentive for the transferring party, the primary insurer, to be as diligent in risk management as it is when it bears the financial consequences of the risk. Specifically in the case of reinsurance, primary insurers might lessen underwriting standards and loss mitigation efforts when they hold reinsurance.

The current study also considers whether the payment of contingent commissions is associated with reserve accuracy. Contingent commission payments are often

[3] See Akerlof (1970) for a discussion of market responses to information asymmetries. See Petroni and Beasley (1996) and Gaver and Paterson (2001) for a discussion of signalling through the choice of third-party auditors.
[4] Borch (1962).
[5] Mayers and Smith (1990).
[6] Garven and Lamm-Tennant (2003).
[7] See, for instance, Doherty and Smetters (2005).

based on an insurer's profitability. Insurers may manage reserves to influence this expense item.

In the next section we review the literature on managerial discretion and loss reserves. The section after that contains a discussion of our empirical methodology. We report and discuss our findings in the subsequent section, followed by the section in which we present a robustness test. The final section includes a summary of the study and suggestions for future research.

Managerial discretion and loss reserve estimation

Loss reserve estimation and its association with managerial objectives have received considerable scholarly attention. While the studies to date have used a variety of different data, different measures of loss reserve errors and different econometric techniques, evidence of an association between insurer reserve errors and managerial objectives has been common. Research has identified several motivations for the management of loss reserves.

Early work by Anderson,[8] Smith[9] and Weiss[10] view income smoothing as a primary goal of loss reserve management. Other things equal, less variability in earnings is associated with higher firm valuations. In addition, it is reasonable to expect that the less the variability in earnings, the lower the likelihood that an insurer will be subject to regulatory attention.

Grace[11] considers income smoothing, while recognising tax minimisation as another managerial goal. Over-reserving errors reduce net income in the current period, thus lowering current period taxes. In time, the redundancy in overstated reserves will become known and taxes will be owed. Nonetheless, the delay in taxes is valuable to the firm as the amount of deferred tax is essentially a zero interest loan from the government.

Grace's research also recognises the benefit that reserve management can have on diverting regulatory attention from an insurer. By under-reserving, the insurer will appear to be financially healthier and, therefore, will be less likely to receive regulatory attention. Petroni[12] finds that financially distressed insurers are more likely to understate loss reserves in order to overstate their financial position. Grace and Leverty[13] question whether firms can divert regulatory attention through reserve management. They contend that a joint hypothesis test is necessary and find that controlling for a number of different possible rationales for errors in reserves reduces the effect of income smoothing and solvency regulation as possible explanations. Their empirical results are not conclusive on whether firms opportunistically manage reserves to avoid regulatory scrutiny. Their work is consistent with insurers' overstating reserves for tax purposes.

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[8] Anderson (1971).
[9] Smith (1980).
[10] Weiss (1985).
[11] Grace (1990).
[12] Petroni (1992).
[13] Grace and Leverty (2011).

Browne *et al.*[14] examine the relationship between the awarding of stock options to executives and the reserving practices of insurers. Their findings suggest that managers of insurers that award stock options engage in reserve management. A reasonable expectation is that financial markets will consider the loss reserves posted by insurers when assessing firm value.[15] Non-naïve valuing of insurers would anticipate opportunistic reporting of reserves.

Research has found that factors beyond managerial control are also associated with reserve errors. Several studies have found that unanticipated inflation is an important factor.[16] Petroni and Beasley,[17] and Petroni *et al.*[18] find that reserving for longer tail lines is more prone to error. The greater uncertainty in the ultimate value of some liability losses through litigation no doubt makes reserving accurately quite difficult. Lei and Schmit[19] find that medical malpractice insurers controlled by physicians are more accurate in establishing reserves than other writers of the coverage. This may be due to an informational advantage these firms hold.

Market signals, such as reinsurance purchases and the use of credible auditors, have the potential to enhance a firm's value by distinguishing the firm from insurers engaging in reserve management. Plantin[20] contends that reinsurance purchases signal reserve *adequacy*. Another possibility is that reinsurance purchases signal reserve *accuracy* because they indicate that the reinsurer is willing to accept a portion of the underlying risks written by the cedent. The information that the reinsurer has of the underlying risks—upon which it makes pricing, financing and managerial decisions—comes primarily from the ceding company, in part through reports of its incurred losses, which include reserve estimates. The reserve levels posted by reinsurers are a function of the reserve levels posted by cedents. Opportunistic reporting of reserves by the primary insurer could negatively impact the operations of the reinsurer who relies on the cedent's estimates.

For instance, if the cedent over-reserves and the reinsurer follows suit, the reinsurer would suffer a decrease in its current period profitability relative to the results it would have achieved if reserving were more accurate. As another example, if the cedent under-reserves and the reinsurer follows, the reinsurer will be subject to greater income taxation than if reserving were more accurate. While in any particular period the interests of the cedent and reinsurer may both be in under-reserving or over-reserving, misinformation from the cedent is strictly harmful to the reinsurer. To the degree the reinsurer wishes to engage in over- or under-reserving itself for whatever strategic purpose, accurate information from each insurer ceding business to it would be highly beneficial. Ultimately, reserving information conveyed by the cedent is more valuable to a reinsurer to the extent it is accurate.

Similar to reinsurers, brokers and agents are sophisticated insurance market participants, frequently have multi-year business relationships with insurers and are

[14] Browne *et al.* (2009).
[15] See, for instance, Beaver and McNichols (2001) and Anthony and Petroni (1997).
[16] See, for instance, Ansley (1979) and Weiss (1985).
[17] Petroni and Beasley (1996).
[18] Petroni *et al.* (2000).
[19] Lei and Schmit (2008).
[20] Plantin (2006).

affected financially by insurers' reserve levels, if their compensation arrangement with the insurer includes a contingent commission. Contingent commission payments made by insurers to intermediaries commonly vary by the size of the book of business the intermediary brings to the insurer and the profitability of the book of business. Under-reserving errors may result in initial excess payments to intermediaries as the understatement inflates the apparent profitability of the book of business. The resulting use of the capital until the time that the actual final loss numbers are known could therefore be costly to the insurer. Over-reserving negatively financially impacts agents and brokers who forego some amount of contingent commission income until and if contingent commissions are adjusted to reflect actual final losses once known. This is financially beneficial to the insurer in the short term; however, it is potentially damaging to its relationships with its intermediaries. We expect that, other things equal, payment of contingent commissions is associated with smaller over-reserving errors and smaller under-reserving errors.[21]

Hypotheses, data, and methodology

To test our hypotheses that reinsurance purchases and the payment of contingent commissions are associated with reserve accuracy, we estimate the following regression equation:[22]

$$
\begin{aligned}
LogAbsError_{i,t} &= \alpha_i \\
&+ Over\text{-}Reserve_{i,t}[\beta_1\ Total\_Re_{i,t} + \beta_2\ Contingent\_Commission_{i,t} \\
&+ \beta_3\ Tax_{i,t} + \beta_4\ Lagged\_ROA_{i,t} + \beta_5\ RBC_{i,t} + \beta_6\ Line\_Herfindahl_{i,t} \\
&+ \beta_7\ Geographic\_Herfindahl_{i,t} + \beta_8\ Group_{i,t} + \beta_9\ Stock_{i,t}] \\
&+ Under\text{-}reserve_{i,t}\ [\beta_{10}\ Total\_Re_{i,t} + \beta_{11}\ Contingent\_Commission_{i,t} \\
&+ \beta_{12}\ Tax_{i,t} + \beta_{13}\ Lagged\_ROA_{i,t} + \beta_{14}\ RBC_{i,t} + \beta_{15}\ Line\_Herfindahl_{i,t} \\
&+ \beta_{16}\ Geographic\_Herfindahl_{i,t} + \beta_{17}\ Group_{i,t} + \beta_{18}\ Stock_{i,t}] \\
&+ \beta_{19}\_1997_{i,t} + \beta_{20}\_1998_{i,t} + \beta_{21}\_1999_{i,t} + \varepsilon_{i,t}
\end{aligned}
\tag{1}
$$

[21] An alternative hypothesis is that insurers inflate reserves to reduce their payments to agents and brokers who are paid contingent commissions. This would arguably be value enhancing to an insurer if the implicit costs of worsened relations with intermediaries as a result of reserve management was less than the benefit gained by overstating incurred losses.

[22] Also included in the regression analysis are variables for 24 lines of insurance. Each variable represents the percentage of business written by an insurer in that line of coverage. In the interest of saving space, we do not report these variables with our results. The 24 individual lines of insurance are Fire, Allied Lines, Farmowners Multiple Peril, Homeowners Multiple Peril, Ocean Marine, Financial Guaranty, Medical Malpractice-Occurrence, Medical Malpractice-Claims Made, Earthquake, Group Accident and Health, Other Accident and Health, Workers' Compensation, Other Liability-Occurrence, Other Liability-Claims Made, Products Liability-Occurrence, Products Liability-Claims Made, Auto Liability (including both private passenger and commercial), Auto Physical Damage, Aircraft (all perils), Fidelity, Surety, Burglary and Theft, Boiler and Machinery, and Credit.

Table 1 provides the definitions of the variables included in our analyses. We more fully describe each variable below.

Dependent variable

Our dependent variable, *LogAbsError*, is the logarithm of the absolute value of the reserve error of insurer i in time period t scaled by total assets. We use this variable to measure the magnitude of the reserve error, which is calculated as follows:

$$Error_{i,t} = (\text{Resest}_{i,t} - \text{Resdev}_{i,t+5})/\text{Total admitted assets}$$

$\text{Resest}_{i,t}$ represents insurer i's initial estimate of loss reserves based on premiums written in period t, while $\text{Resdev}_{i,t+5}$ is insurer i's developed loss reserve in year $t+5$ arising from premiums earned during period t. The difference between these two variables is the reserve error for insurer i. An insurer's initial loss reserve estimate is found by the difference between estimated incurred losses and cumulative losses paid in a particular year. The developed loss reserve estimate in year $t+5$ is calculated by subtracting the cumulative losses paid from the revised incurred loss estimate

Table 1 Variable definition

Variable	*Definition*
LogAbsError	Log (Absolute value of KFS Error), where KFS Error is the difference between insurer i's incurred losses in year t and revised incurred losses in year $t+5$
Total_Re	Log (Premiums ceded to reinsurers scaled by total premiums written $+1$)
Contingent_Commission	Dummy variable equal to 1 if amount of contingent commissions is positive and 0 otherwise
Tax	Marginal tax rate corresponding to the sum of reported net income and the reserve error
Lagged_ROA	Ratio of the sum of underwriting income, investment income and estimated reserves to total assets in $t-1$
RBC	Ratio of total adjusted capital to authorised control level risk-based capital
Individual P/C Line	Percentage of net premiums written in each of the 24 P/C lines included in this study
Line_Herfindahl	$\sum_L (DPW_L/TPW)^2$, where DPW_L is the amount of direct premiums written on a particular P/C line while TPW is the amount of total premiums written across all P/C lines included in this study
Geographic_ Herfindahl	$\sum_S (DPW_S/TPW)^2$, where DPW_S is the amount of direct premiums written in a particular state while TPW is the amount of total premiums written across all states
Group	1 if affiliated with a group, 0 otherwise.
Stock	1 if stock insurer, 0 otherwise.

five years afterwards. In other words, the reserve error is the difference between incurred losses in the current year and the revised estimate of incurred losses for that year five years later. In the academic literature on reserve errors, this reserve error, developed by Kazenski *et al.*,[23] is commonly referred to as the KFS error.[14,24] We use a five-year development period as it is the most frequent in the literature and it is felt to be a sufficiently long enough period for the reserve error to be detected, if it is present.[24,25] Data for calculating the reserve errors is found in Schedule P of each insurer's annual financial statement.

Positive reserve errors indicate over-reserving. Negative errors indicate under-reserving. The variables *Over-Reserve* and *Under-Reserve* on the right-hand side of the regression equation indicate the direction of the reserve error. In the regression equation, each of these two variables is interacted with the same set of explanatory variables.

Reinsurance variable

To test whether the purchase of reinsurance is associated with loss reserve accuracy, we construct the variable *Total_Re*, as the log of the ratio of premiums ceded to reinsurers to total premiums written.[26] We expect that to address potential moral hazard, the monitoring of cedents by reinsurers increases as the percentage of its book of business reinsured increases. Consequently, we expect that reserve accuracy increases as the percentage of the cedent's book of business transferred to reinsurers increases.

Contingent commission variable

We construct the variable *Contingent Commission* to test whether reserve errors are associated with this form of payment to market intermediaries. *Contingent Commission* is a dichotomous variable that takes the value 1 if the insurer pays contingent commissions and the value 0 otherwise.

Control variables

We include the following control variables in our regression equation.

Tax is included to control for the effects of taxation on a primary insurer's reserving behaviour. Grace[11] contends that for profit maximising insurers the primary purposes of reserve management are tax minimisation and income smoothing. Graham[27] finds that the statutory marginal tax rate is a reasonable proxy for a company's tax

[23] Kazenski *et al.* (1992).

[24] Another commonly used measure of loss reserve error is the Weiss error, which is defined as the difference between incurred losses in the current year and cumulatively developed losses paid several years later (Grace and Leverty, 2011). We use the KFS error as the Weiss error is biased upward and may be highly associated with the length of the claims tail.

[25] Since the number of years of data used to estimate the test equation is inversely related to the development period, extending the development period reduces the sample size.

[26] Reinsurance purchased is taken from "Underwriting and Investment Exhibit, Part 2B—Premiums Written". We add one to the ratio before taking the log transform.

[27] Graham (1996).

exposure. We add the insurer's reserve error in year t to its reported net income in year t to determine the marginal tax rate that would have been applicable had the insurer estimated its reserves accurately.[28] Other things equal, we expect that insurers facing a higher statutory marginal tax rate will over-reserve more and under-reserve less.

Income smoothing, as the term suggests, involves reducing fluctuations in income over time. Prior research[11] suggests that insurers may manage reserves to smooth income. Petroni *et al.*[18] use return on assets (defined as the ratio of net income to total assets) to control for insurers' incentive to engage in reserve management to smooth earnings. They find that higher returns on assets are associated with greater over-reserving errors and lower under-reserving errors, other things equal. One limitation of using return on assets is that the net income used in the calculation already takes into account reserve estimation. In our study, we use a modified return on assets (*Lagged_ROA*), which is the ratio of (net income + loss reserve) to total assets.[29] We add the loss reserve back to net income because pre-reserve income is the basis for any potential reserve management.

To control for the financial condition of insurers in the study, we include in our model the risk-based capital (RBC) ratio, which is defined as the ratio of total adjusted capital to authorised control level RBC.[30] A higher value of the ratio indicates a stronger financial position. We anticipate that insurers with higher RBC ratios tend to report more accurate reserving estimates. Petroni[13] finds that insurers with weak ratings make greater under-reserving errors, other things equal.

Petroni and Beasley[17] find that firms with greater writings of long-tail lines make greater reserving errors. Cole and McCullough[31] report that the demand for reinsurance by a primary carrier depends upon the lines of coverage it writes. To control for differences across lines of coverage, we include as control variables the per cent of business written in each of 24 different property and casualty lines.[22] Due to the inherent difficulty of estimating reserves for longer-tail lines, variation in estimation across lines is expected.

To control for the concentration of an insurer's book of business and business locations, both *Line_Herfindahl* and *Geographic_Herfindahl* indicators are included in our models. The definitions of each follow:

$$\text{Line\_Herfindahl Index} = \sum_{L} \left(\frac{DPW_L}{TPW} \right)^2$$

[28] Please see *http://www.taxfoundation.org/taxdata/show/2140.html.*

[29] This variable is lagged one period to account for endogeneity.

[30] In addition to RBC, we have also experimented with two other sets of measures that proxy insurers' financial condition. The first set is based on insurers' A.M. Best's ratings from which we created various categorical variables. The second set follows Petroni (1992) and includes dummy variables corresponding to the number of Insurance Regulatory Information System (IRIS) ratios associated with an insurer that are outside the proscribed normal range. An insurer is considered to be in a weak financial position if there are more than three IRIS ratios outside the normal range. We found that inclusion of these alternative measures in our models did not change our main results. The only difference we found was that RBC was significant in some of our regressions, whereas the alternative variables were always insignificant.

[31] Cole and McCullough (2006).

$$\text{Geographic\_Herfindahl Index} = \sum_{S} \left(\frac{DPW_S}{TPW} \right)^2$$

where, DPW_L is the amount of direct premiums written in a particular property and casualty line and TPW is the amount of total premiums written across the property and casualty lines. Insurers with a higher value for the line-of-business Herfindahl have greater concentration in their lines of coverage. The range of this index is between 0 and 1.

In regard to the geographic Herfindahl index, DPW_S is the amount of direct premiums written in a particular state and TPW is the amount of total premiums written in all states. The higher the geographic Herfindahl index, the more geographically concentrated is an insurer's book of business. The range of this index is between 0 and 1.

The effect of the two Herfindahl indices on the size of the reserve error could be twofold. On the one hand, a more specialised firm in terms of its book of business may have more expertise in its underwriting practices in the lines in which it specialises and consequently have greater ability to estimate accurate reserves. Similarly, since local insurers with high geographic Herfindahl indices are believed to have superior informational advantages in their area, they may be more skilled in underwriting and reserving. On the other hand, firms that are concentrated either in line of business or geographically are less diversified. Thus they may be more conservative in their loss reserving practices, possibly resulting in greater over-reserving errors.

The binary variables *Group* and *Stock* are used to capture group affiliation and ownership structure influences on reserve errors, respectively. *Group* equals 1 if the primary insurer is a company within a group, and is set to 0 otherwise. *Stock* equals 1 if the primary insurer is organised as a stock company, and 0 otherwise. Both group affiliation and organisational type have been found in prior literature to be associated with the size of reserve errors.

In addition, a series of year dummies spanning the study period 1997–2000 is included to control for possible time effects.

We employ National Association of Insurance Commissioners (NAIC) data from 1997 to 2005. Since we use a five-year loss development period in our calculation of reserve errors, the actual data included in our study is for years 1997 through 2000. The NAIC data set includes annual statement information supplied yearly to state insurance departments.

Overall, our sample consists of 4,797 observations on an insurer-year basis. We include in our sample all insurers who report a positive value for net premiums written and a positive value for total assets. Missing values for any of the variables in our models preclude an insurer from being included in our sample. Insurers who reported negative values for either reinsurance premiums or contingent commission payments were also not included.

Table 2 reports summary statistics for the variables included in our analyses. The mean value of the KFS error is −0.032, which indicates that on average the insurers included in our sample under-reserved during 1997–2000. Out of the 4,797 observations, 2,803 were associated with over-reserving firms that had an average

Table 2 Summary statistics, 1997–2000 ($N = 4{,}797$)

Variables	*N*	*Std Dev*	*Min*	*Q1*	*Median*	*Mean*	*Q3*	*Max*
KFS Error	4797	1.559	−77.462	−0.028	0.007	−0.032	0.045	4.107
KFS Error (O)	2803	0.132	0	0.014	0.036	0.064	0.077	4.107
KFS Error (U)	1994	2.408	−77.462	−0.103	−0.041	−0.166	−0.013	0
LogAbsError	4797	1.525	−12.069	−4.280	−3.287	−3.482	−2.456	4.350
Total_Re	4797	0.212	0	0.0980	0.262	0.290	0.474	0.752
Contingent_Commission	4797	0.497	0	0	1	0.556	1	1
Tax	4797	0.128	0	0.34	0.340	0.291	0.350	0.390
Lagged_ROA	4797	0.067	−1.494	0.012	0.031	0.030	0.052	0.732
RBC	4797	158.906	−0.690	4.965	7.442	18.590	12.002	7518.3
Line_Herfindahl	4797	0.289	0.090	0.266	0.451	0.512	0.726	1
Geographic_Herfindahl	4797	0.109	0.050	0.294	0.395	0.399	0.500	1
Group	4797	0.462	0	0	1	0.693	1	1
Stock	4797	0.456	0	0	1	0.705	1	1

reserve error equal to 0.064 per cent of assets. On the other hand, 1,994 observations were related to under-reserving insurers. The mean value of the reserve error for these firms is −0.166 per cent of assets.

Approximately 55.6 per cent of the observations in our sample are from firms that paid contingent commissions. The average tax rate insurers were subjected to is 29.1 per cent. On average firms in our sample earned a 3 per cent return on assets. The line of business Herfindahl index averages 0.512. The geographic Herfindahl index averages 0.399. Around 69.3 per cent of the observations are associated with firms belonging to a group and 70.5 per cent are related to stock companies.

Table 2 shows that the median and the mean values were quite different for the KFS error and a few other variables (such as *RBC* and *Tax*), indicating potential skewness of the data. We also notice some extreme values. For instance, the minimum value of the KFS error is −77.462, which is far different from the first quartile −0.028. To test the robustness of our results, we removed observations for which any variable was in the top or bottom 1 per cent of the values for that variable. We then ran our analysis again on the smaller sample. We obtained largely similar results, which are reported in the "Robustness test" section where we discuss our robustness test.

Empirical results

To test our hypotheses, we estimate one-way fixed-effects models with subject-specific intercepts to yield heteroscedastistic-consistent estimators.[32] Both the White and Breusch-Pagan tests had indicated a serious heteroscedasticity problem. Variance

[32] In other words, we have separate intercept terms for each insurer in the sample, which helps control insurer-specific differences between companies.

Table 3 Empirical results for fixed-effects model with firm-specific intercept ($N = 4{,}797$)

Variables	*Estimate*	*Standard Error*
Over-Reserve		
Total_Re	−0.638***	0.191
Contingent_Commission	−0.143**	0.074
Tax	1.257***	0.361
Lagged_ROA	−1.156***	0.410
RBC	2.00E-05	2.70E-04
Line_Herfindahl	−0.407***	0.153
Geographic_Herfindahl	0.504**	0.256
Group	−0.247***	0.084
Stock	−0.099	0.083
Under-Reserve		
Total_Re	0.317	0.219
Contingent_Commission	0.087	0.092
Tax	−2.636***	0.219
Lagged_ROA	0.698	0.441
RBC	−0.002*	0.001
Line_Herfindahl	−0.133	0.197
Geographic_Herfindahl	0.370	0.360
Group	0.060	0.111
Stock	0.101	0.116
1997	−0.008	0.055
1998	−0.091*	0.051
1999	−0.079**	0.040
−2Loglikelihood	15,721.8	

Note: *** means significant at the 1 per cent level, ** 5 per cent level and * 10 per cent level.

Inflation Factor (VIF) values for all independent variables are below 10, indicating that multicollinearity is not a concern with our data. Hausman tests did not detect endogeneity between our loss reserve error variables and our major independent variables. To control for time effects, year dummies, *_1997*, *_1998*, and *_1999* are included in our models. Table 3 presents the regression results.

At the 1 per cent level of statistical significance, our results indicate a negative relationship between the amount of reinsurance purchased by insurers and the magnitude of their over-reserving errors. In contrast, we do not find that the purchase of reinsurance is associated with under-reserving errors.

In addition, our empirical results provide support for our hypothesis of a relationship between the payment of contingent commissions and reserving errors. Specifically, we find a negative relationship between the payment of contingent commissions and the magnitude of over-reserving errors. We do not find a statistically significant relationship between the payment of contingent commissions and the size of under-reserving errors.

As expected, the variable *Tax* is positively associated with over-reserving errors, and negatively related to under-reserving errors. In both over- and under-reserving directions, this variable is statistically significant at the 1 per cent level. Firms that

over-reserve report less taxable income, other things equal. Insurers facing higher tax rates have a greater financial incentive to over-reserve to reduce their taxable income and corresponding tax liability. Similarly, firms that under-reserve increase their tax liability by inflating their taxable income. Our results are consistent with firms making smaller under-reserving errors when under-reserving errors are more costly in terms of creating greater tax liability, other things equal. These findings provide support for Grace's[11] hypothesis that insurers with greater taxable income make greater over-reserving errors in order to delay the payment of taxes.

We find that return on assets, which in our model is the variable *Lagged_ROA*, is negatively associated with over-reserving errors at the 1 per cent level of significance. This suggests that firms that earn higher rates of return report lower over-reserving errors. We do not find any significant relationship between this variable and the size of under-reserving errors. These results are contrary to Petroni *et al.*,[18] who find that higher returns on assets are associated with greater over-reserving errors and smaller under-reserving errors. Recall that our measure differs from Petroni *et al.* in that we deducted the value of loss reserves off net income before calculating our return on assets.

We find that RBC is negatively related to the size of under-reserving errors. This is consistent with Petroni[12] who found that insurers with weak ratings make greater under-reserving errors, other things equal.

Our regression results indicate that there is a positive relationship between the geographic Herfindahl index and the size of over-reserving errors; however, we find no statistically significant relationship between the index and the magnitude of under-reserving errors. In contrast, our insurance line Herfindahl index is negatively associated with over-reserving errors. As indicated earlier, higher values of *Line_Herfindahl* or *Geographic_Herfindahl* would be expected to be associated with lower over-reserving errors if more narrowly focused writers have greater knowledge of their book of business and thus more accurate reserving practices. At the same time, since these insurers lack diversification, they may be more conservative in their reserving practices and consequently report greater over-reserving errors.

Our results suggest that insurers that belong to a group make smaller over-reserving errors. The year variables corresponding to 1998 and 1999 are both negative and statistically significant in our models.[33] Controlling for inter-temporal variation in the models is warranted.

Robustness test

To test the robustness of our regression results, we estimated our model a second time after removing from our sample observations for which any variable value was in the top or bottom 1 per cent of the distribution of that variable over the entire sample. This resulted in a smaller sample of 4,447 observations. We again ran the same regression equation and report the results of this robustness test in Table 4.

[33] In the interest of saving space, we do not report the coefficients for the company intercept terms in our fixed-effects models or the coefficients for the lines of business variables. Many of these were significant.

Table 4 Empirical results for fixed-effects model with firm-specific intercept ($N = 4{,}447$)

Variables	*Estimate*	*Standard Error*
Over-Reserve		
Total_Re	−0.471***	0.158
Contingent_Commission	−0.227***	0.068
Tax	1.475***	0.316
Lagged_ROA	−0.883*	0.526
RBC	−0.013***	0.002
Line_Herfindahl	−0.173	0.140
Geographic_Herfindahl	0.613**	0.247
Group	−0.150*	0.080
Stock	−0.057	0.079
Under-Reserve		
Total_Re	0.327*	0.187
Contingent_Commission	0.077	0.083
Tax	−2.342***	0.187
Lagged_ROA	1.267*	0.705
RBC	−0.006***	0.002
Line_Herfindahl	−0.083	0.175
Geographic_Herfindahl	−0.131	0.305
Group	0.040	0.103
Stock	0.237**	0.107
1997	−0.051	0.051
1998	−0.126***	0.046
1999	−0.126***	0.036
−2Loglikelihood	13,368.9	

Note: *** means significant at the 1 per cent level, **5 per cent level and *10 per cent level.

The results using the smaller sample are largely consistent with those using the primary sample. Again, we observe a negative and statistically significant relationship between the amount of reinsurance purchased and the magnitude of over-reserving errors. We also find that greater amounts of reinsurance are associated with greater under-reserving errors, this time with a smaller standard error of 0.187 and a larger p-value of 0.08. These results indicate that the purchase of reinsurance may encourage insurers, other things equal, to reserve less, perhaps in an attempt to improve the appearance of their book of business and obtain better terms from their reinsurers.

As with our larger sample, we find a negative and statistically significant relationship between the payment of contingent commissions and the size of over-reserving errors. Again we find no statistically significant relationship between the payment of contingent commissions and the size of under-reserving errors.

While the direction, coefficient estimate and statistical significance of our control variables in our smaller sample model are largely similar to those in the larger sample estimation, our findings relating to our measure of insurer solvency, *RBC*, differ between the models. In our smaller sample model, this measure is statistically significant for both under- and over-reserving errors. In both cases, the relationship is negative suggesting that firms with greater levels of RBC reserve more accurately.

A possible explanation for this finding is that firms with superior management hold greater amounts of RBC and reserve more accurately.

Conclusion

Prior research has found evidence that insurer reserve errors are associated with possible corporate objectives, including tax minimisation and income smoothing. We hypothesise that insurers may also strategically err in estimating their reserves to affect the payment of contingent commissions to intermediaries and the terms that are able to be negotiated with reinsurers. We empirically test our hypotheses using NAIC data from the U.S. property and casualty insurance industry.

Our results suggest reinsurance purchases are negatively associated with the magnitude of over-reserving errors. We do not, however, observe a statistically significant relationship between reinsurance purchases and the size of under-reserving insurers. Since over-reserving errors make insurers' books of business appear worse, it is reasonable to expect that the errors would negatively impact the terms insurers are able to obtain from reinsurers. Although under-reserving errors would make insurers' books of business appear better to reinsurers than they actually are, we do not find strong evidence of this relationship in our analyses. A possible explanation for this is that reinsurers simply may not be fooled by under-reserving errors into offering better terms.

Similar to our findings regarding reinsurance purchases, we find that the payment of contingent commissions is associated with smaller over-reserving errors. We find no evidence that the payment of contingent commissions is associated with the magnitude of under-reserving errors. We anticipate that although over-reserving errors will have the effect of decreasing contingent commission payments in the short term, this would have the potential to damage an insurer's relationships with its brokers and agents when true underwriting results are revealed with the passage of time. *A priori*, which influence dominates is not clear. Our empirical results suggest that the potential cost of damaged relations with market intermediaries outweighs the potential financial benefit that would be derived from over-reserving. The data for this study is from U.S. insurers. Future work focusing on insurers in other countries is warranted.

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