Leverage and Reinsurance Effects on Loss Reserves in the United Kingdom's (UK) Property-Casualty Insurance Industry

Abstract

We examine the relation between loss reserving errors, leverage and reinsurance in the UK's property-casualty insurance industry. We find that financially weak insurers under-estimate reserves to reduce leverage, and so pre-empt costly regulatory scrutiny. However, at very high leverage, insurers over-reserve, suggesting a non-linear relation between leverage and reserving policy. We also investigate whether monitoring by reinsurers reduces reserving errors, and find that highly reinsured insurers are less likely to make loss reserve errors. However, the use of proportional reinsurance does not affect loss reserve accuracy.

Keywords: leverage; reinsurance; loss reserves; insurance; UK.
JEL Classification: G22.

1. Introduction

In this study, we investigate the effects of UK property-casualty insurers' solvency (leverage) and risk management (reinsurance) practices on accounting accruals adjustments on insurance loss reserves. The loss reserve is the largest balance sheet item for insurance firms and derives from an actuarial estimate of an insurer's liability for unpaid claims (plus associated loss adjustment, legal and other expenses) on incurred (but not necessarily fully reported) losses - usually over the previous five accident years (Grace and Leverty, 2010, 2012). Measures of loss reserve errors therefore reflect accounting differences between the forecast and actual claims outcomes payable under insurance contracts (Nelson, 2000).

The UK's property-casualty insurance industry is an interesting setting for conducting accounting accruals-based earnings management research. First, statutory accounting data are publicly available thus enabling managerial bias in loss reserving, and its link with solvency and risk management to be examined (Weiss, 1985). Second, there are costs for insurance firms associated with the discretionary manipulation of earnings via loss reserves, which in extreme cases could result in regulatory receivership (Hoyt and McCullough, 2010). Third, in writing generally non-tradable contingent financial claims contracts, insurers, like banks, are more highly leveraged than most other commercial entities (Harrington and Niehaus, 2003). This makes the maintenance of solvency, loss reserve accuracy, and risk management important strategic issues for property-casualty insurers and other financial firms. Such considerations have spawned a large number of studies examining the impact of loss reserve accruals on reported earnings, solvency reporting, and firm valuation – most notably in the United States (US) property-casualty insurance industry (e.g., see Petroni, 1992; Gaver and Paterson, 2004; Eckles and Halek, 2010).

Regulatory and other institutional (e.g., accounting and fiscal) differences between the US and other insurance markets, such as the UK, could influence corporate financial reporting decisions in different ways. One example of accounting treatment differences between jurisdictions concerns the use of reserve discounting. Statutory insurance accounting rules in the US prohibited the discounting of loss reserves, whereas in the UK and other countries (e.g., Australia), insurance regulations have allowed a degree of reserve discounting, especially for long-tail insurance contracts (e.g., legal liability), where claims settlements can extend over several years (D'Arcy, Au and Zhang, 2009).Transnational regulatory and accounting differences could therefore affect the discretion insurance managers have in manipulating loss liabilities (e.g., through the choice of discount rates) and meeting other strategic (e.g., earnings) targets. Indeed, the greater degree of managerial discretion over reserve discounting in the UK could, all else equal, increase the propensity for loss reserve errors, and hence, weaken corporate solvency compared with the US.

Our study has two key goals. First, we examine the relation between UK insurers' leverage and loss reserve accruals. Leverage management motives for loss reserving have political as well as economic importance for insurance firms as they are subject to ongoing statutory solvency monitoring and prudential controls by industry regulators (Serafeim,2011). Specifically, we examine the linear and the non-linear effects of leverage on the accuracy of loss reserves given that prior research (e.g., Purnanandam, 2008) suggests a non-linear relation between leverage and risk hedging. Dechow, Ge and Schrand (2010) add that in financial services, there is often a direct link between loss reserve accruals and capital requirements - a factor that heightens the regulatory significance of research such as ours.

Second, we examine whether reinsurance and the monitoring function of reinsurers influence the accuracy of loss reserves. Adiel (1996) notes that reinsurance creates opportunities for managers to meet statutory solvency requirements, and other strategic objectives. However, the linkage between the type of reinsurance used (e.g., proportional and non-proportional treaties) and reserving errors has not been examined previously. This relation is important from both commercial and regulatory perspectives given that strategic decisions regarding the form and mix of reinsurance purchased can directly influence levels of reserves and the reported solvency positions of insurance firms (Eden and Kahane, 1988). Therefore, the present study adds to the literature on financial contracting, risk management, and their links with corporate accounting and financial reporting practices.

The current study makes four contributions. First, we observe that financially weak insurers under-state reserves in order to reduce reported claims liabilities (leverage) and enhance their accounting position. These results accord with many prior US-based studies (e.g.,Petroni, 1992; Gaver and Paterson, 2004; Grace and Leverty 2010). For the first time, we also find that when insurers' leverage is 'very high' (i.e., where the ratio of claims liabilities to total assets is around 90%), insurers over-reserve for future liabilities[1]. Indeed, under statutory powers granted under sections 138 and 166 of the Financial Services and Markets Act (FSMA) (2000), the UK's insurance industry regulator can actively require financially weak (low income) insurers to raise additional capital and/or reserves.

Second, we find that the amount of reinsurance purchased by UK insurers reduces reserving errors. We argue that this is because reinsurance enables primary insurers to effectively hedge underwriting risks and lower levels of reserves (Abdul Kader, Adams and Mouratidis, 2010). Reinsurance also allows insurers to benefit from the oversight and risk management advice provided by their reinsurer partners (Plantin, 2006). However, insurers' use of proportional reinsurance does not significantly affect the accuracy of loss reserves.

Third, our UK study adds to prior (mainly US) research by showing that the managers of insurance firms behave differently (e.g., in terms of their risk management practices) as a consequence of the nature of the regulatory regime under which they operate. This condition could apply equally to the reserving practices of other financial firms such as banks and life insurers.

Fourth, our use of a dynamic panel data design - System Generalized Method of Moments (GMM-SYS) - controls for contemporaneous correlation and other issues (e.g., simultaneity between reserving and reinsurance) as well as time-specific factors, notably underwriting cycles, that might affect loss reserves as a result of temporal changes in market premiums, earnings performance, and levels of capital[2]. These aspects of our research design advance on prior research and enhance the robustness of our results.

The remainder of our paper proceeds as follows. In the next section, we give an overview of the main regulatory differences between UK and US property-casualty insurance markets. In section 3, we motivate and formulate our research hypotheses. In section 4, we describe our sources of data, specify the modeling procedure, and describe the variables used. Section 5 then presents the empirical results, while section 6 concludes.

2. Comparison of UK and US Insurance regulation

Before 2000, the UK statutory accounting framework for insurers was governed by various insurance company statutes - notably the 1994 Insurance Companies Regulations, which monitored solvency on a regulatory test-ratio basis similar to the pre-1994 solvency surveillance system in the US (e.g., see Hoyt and McCullough, 2010). However, after the passage of FSMA (2000), and in the wake of high profile under-reserving induced insolvencies of property-casualty insurers, such as Independent Insurance plc (2001) in the UK and the HIH insurance Group (2001) in Australia, the UK adopted a more proactive and holistic 'individual risk-based capital assessment' for all licensed insurance firms. This firm-level risk-based regulatory approach in the UK assesses an insurer's 'probability of ruin' not only in terms of quantitative financial criteria, such as leverage and liquidity, but also qualitative aspects, such as the risks associated with boardroom strategies. This approach was fully formalised in 2003/4 by the pre-2013 unitary regulatory authority - the Financial Services Authority (FSA) (Eling and Holzmüller, 2008).[3]

Unlike their UK counterparts, the accounting treatments and financial reporting practices of US publicly listed insurance firms are also subject to potential enforcement actions of the Securities and Exchange Commission (SEC) and the Sarbanes-Oxley (SOX) Act (2002) (Hart, 2009). Therefore, regulatory differences in the reserving for insurance losses could influence the financial decisions of UK insurance managers in distinct ways compared with their counterparts in the US. Indeed, giving UK insurance managers regulatory discretion as to which insurance liabilities to discount, and in setting discount rate assumptions (e.g., on future inflation and interest rates) could, as we noted earlier, lead them to estimate the direction and scale of loss reserve errors differently compared with their US counterparts[4].

The UK's system of unregulated premium rating could further impact on how insurers build reserves in ways that are dissimilar from the US where regulatory limits of premiums is common in many states (e.g., New York state). For example, unregulated insurance premium rating allows insurers to adjust premiums to 'actuarially fairly' reflect the exposure of risks underwritten and other market (e.g., investment) conditions pertaining at the time business is written. This could enable UK insurers to more accurately estimate reserves, reduce reserving errors, and so better protect insurers' solvency position compared with US insurers operating in premium regulated environments, such as New York state. Cole and McCullough (2006) also note that in the US, regulations discriminate between domestic US reinsurers and foreign (‘alien’) reinsurance companies by prescribing that US primary insurers maintain higher capital ratios ('collateralization') if they reinsure with an unauthorised foreign reinsurer compared with a US reinsurer. Therefore, all else equal, financially weak US primary insurers reinsuring with unauthorised foreign reinsurers are expected to have a relatively high incidence of under-reserving error, and thus, more likely to engage in earnings management (Petroni,1992). In contrast, the UK's insurance regulations do not discriminate between domiciled and non-domiciled reinsurance suppliers. This means that in the UK, insurers are prospectively better able than their US counterparts to cost-effectively manage their solvency position using an optimal mix of reserving and reinsurance strategies. This aspect of the UK's 'lighter touch' insurance regulatory environment further provides for a potentially direct test of the reinsurance-reserving relation.

3. Hypotheses

In this section, we outline two alternative hypotheses (H1A and H1B) regarding the relation between leverage and the direction/scale of loss reserving errors, and then consider the expected contingent capital effects of risk reinsurance on the level of loss reserves (H2) and their accuracy (H3 and H4).

3.1. Effect of leverage on loss reserving errors

Cummins and Sommer (1996) acknowledge that insurers' profitability directly affects solvency, and that increased financial distress/bankruptcy risk lowers the market demand for insurance in the face of limited government guarantee funds. As noted earlier, several US studies (e.g., Petroni, 1992; Beaver, McNichols and Nelson, 2003; Gaver and Paterson, 2004) document that managers in financially troubled insurers use discretionary accruals to under-state loss reserves in order to reduce reported loss liabilities (i.e., improve solvency). Such action allows insurers to avoid not only the disruption costs of regulatory scrutiny, but also the associated economic loss of a drop in new business premiums due to the perceived enhanced risk of financial distress/bankruptcy amongst policyholders. Therefore, the more discretion given by UK regulators to insurance managers over the assumptions and rates used to discount reserves (e.g., with respect to losses on long-tail lines of insurance), the greater the scope for reserve under-statement. The release of funds from under-stating reserves can be further used to improve accounting period profitability (and so help managers meet bonus targets) and/or increase dividends to shareholders, thereby, promoting firm value (Eckles, Halek and Zhang, 2014). Such incentives are consistent with the motives for earnings management not only in financial firms, but also for firms operating in other industries (e.g., see Atieh and Hussain, 2012). Therefore:

H1A: Highly leveraged property-casualty insurers (linearly) under-state loss reserves.

Research acknowledges that determining the optimality of solvency (leverage), and risk management (reinsurance) is a complex phenomenon that could have a non-linear (non-monotonic) effect on accounting numbers. For example, Purnanandam (2008) argues that financial distress costs associated with increased leverage can motivate firms to engage in risk management. However, the incentives to hedge risks dissipate at extreme levels of leverage as the 'default put option' of shareholders' equity under limited liability rules becomes more valuable. This implies that insurance firms that gain the most from reserve accruals management may neither be the most financially weak nor the most financial strong operators in the industry, suggesting a non-monotonic (non-linear) relation between leverage and loss reserving errors. Under statutory powers granted under sections 138 and 166 of the FSMA (2000), the UK's insurance industry regulator can require financially weak insurers to review their commercial practices, and if necessary, raise equity and/or set aside deficiency reserves in cases where unexpired risks are deemed to have been under-priced (e.g., in order to maintain product-market share) and/or where investment returns are lower than expected (e.g., due to unforeseen macroeconomic conditions).[5] Regulatory pressure for financially fragile UK property-casualty insurers to maintain 'safety' reserve margins to offset unexpectedly severe losses is particularly likely to be needed in liability and catastrophe insurance lines where the quantum and timing of incurred, but not reported (IBNR) claims are often difficult to accurately estimate ex-ante (Zanjani, 2002). This implies that UK insurers in acutely weak financial condition will be unable to continuously under-reserve their liabilities in order to improve their leverage position as pressure from the industry regulator - particularly in a unitary regulatory environment such as the UK - would lead to them to over-reserve in a non-linear manner. As a result:

H1B: Highly leveraged property-casualty insurers (non-linearly) over-state loss reserves.

An argument relevant to understanding the loss reserving-solvency risk relation, particularly in terms of the role of reinsurance, is provided by Harrington and Danzon’s (1994) ‘moral hazard' hypothesis. This hypothesis holds that due to the ‘default put option’ feature of corporate limited liability and the existence of government policyholders' guarantee funds (as exists in the UK), the managers of highly leveraged insurers could be motivated to increase levels of reinsurance not only to reduce underwriting and insolvency risks, but also to increase rates of new business (positive cash flow). In this way, purchasing reinsurance substitutes for capital and reserves, thereby, allowing managers to release funds (reduce leverage/increase earnings) to satisfy other objectives, such as the meeting of new sales and/or executive bonus plan targets. Increasing reinsurance can also protect policyholders and other constituents (e.g., minority shareholders) from agency problems, such as the underinvestment incentive (e.g., see Garven and MacMinn, 1993).[6] Therefore, increasing reinsurance can strengthen insurers' balance sheets by reducing reported liabilities (reserves) and improve reported earnings. As a consequence:

H2*:* Highly leveraged property-casualty insurers with high rates of new business growth increase reinsurance to reduce loss reserves.

3.2. Effect of reinsurance on the accuracy of loss reserves

Although the transaction costs of reinsurance reduce the free cash flows of insurance firms (Shiu, 2011), it nevertheless helps managers smooth period earnings, and therefore, potentially reduces the need for earnings management (Garven and Lamm-Tennant, 2003). Reinsurance enables primary insurers to retain smaller risk exposures and reinsure larger ones, thereby, reducing their future claims' liabilities (Abdul Kader et al., 2010). Monitoring by reinsurers of primary insurers' business activities can also play an important role in alleviating information asymmetry problems in insurance markets (Plantin, 2006). As such, reinsurers can usefully complement regulatory oversight - an important attribute in 'light touch' regulatory regimes, such as the UK's insurance market. For example, reinsurers will closely monitor the underwriting and claims settlement practices of primary insurers, and if necessary, adjust ex-post reinsurance commissions (which they pay an insurer) and reinsurance premiums (which they charge an insurer) in the event of greater than anticipated loss experience by the primary insurer (Jean-Baptiste and Santomero, 2000). Plantin's (2006) notion of the 'credible signaling' benefit of reinsurance further implies that highly reinsured insurers are likely to be subject to a greater degree of oversight by reinsurance managers, and thus, have lower reserve errors than less reinsured insurance firms. Accordingly:

H3: Highly reinsured property-casualty insurers report more accurate loss reserves.

Eden and Kahane (1988) argue that the form of reinsurance treaty used can also affect the risk and capital management decisions of insurance firms. Under proportional reinsurance (e.g., a quota-share treaty), the insurer and reinsurer share premiums and losses proportionally. Proportional reinsurance spreads the risk of loss and creates a 'broad identity' of financial interests between the insurer and reinsurer. As such, the reinsurer is able to acquire information on the adequacy of the insurer's capital, reserves and risk management systems, and therefore, act as an effective monitor of an insurer's underwriting and other operations. In contrast, under non-proportional reinsurance (e.g., an excess-of-loss treaty), the reinsurer does not participate in every loss event. If losses to the insurer are less than the retention specified in the reinsurance treat, then the reinsurer owes nothing to the primary insurer. Therefore, all else equal, an insurer does not need to disclose as much risk analysis data and other business information under non-proportional reinsurance compared with proportional reinsurance. As a result of potentially high information asymmetries associated with non-proportional reinsurance, a reinsurer is likely to become a relatively less effective monitor of an insurer's business operations than in cases where proportional reinsurance is used (Eden and Kahane, 1988).[7] Thus:

> H4: Property-casualty insurers that predominantly use proportional reinsurance report more accurate loss reserves.

4. Research Design

4.1. *Sampling procedure*

Standard & Poor's *SynThesys* UK non-life insurers' database was used to derive our panel sample. This database provides details on the annual solvency returns submitted to the regulator by UK-licensed insurance firms (which for the purpose of the present study was the period from 1985 (the first year of data) to 2010 (the latest year available to us at the time the study was carried out)). The unbalanced panel data set that we use covers firms licensed to write insurance in the UK. Regulatory returns are also filed separately for each trading entity within conglomerate insurance groups. Before 1996, UK property-casualty insurers were only required to disclose their loss development history for the previous five accident years. More recent actuarial reserve estimation techniques usually require a five to nine-year resolution period to estimate *Incurred/Developed Losses* at *t+5* (Grace and Leverty, 2012). This reduced the reserve error sampling period from 1991 to 2005. There were also mergers and acquisitions (particularly during the late 1990s) and intra-company restructurings in the UK's property-casualty insurance industry, which could affect reported financial data. Therefore, we applied the following conditions in the sampling procedure in order to conduct our analysis. First, missing values for any of the variables used in the models preclude an insurer from being included in the sample. Second, insurers must have positive reserves, incurred losses, total assets, and gross premium written as well as at least three consecutive years of complete data. This results in an unbalanced dataset of 1,386 firm/year cases covering 151 UK property-casualty insurers. The panel sample comprises approximately 50% of the population of active UK-based property-casualty insurers over the period of analysis. Of these firms, approximately 95% are stock insurers. This precludes a separate analysis of loss reserving differences between the stock and mutual forms of insurance organization that has been carried in some prior US research (e.g., Lamm-Tennant and Starks, 1993). Otherwise, the final panel data set includes a representative mix of insurers of different size, product-mix, and stock ownership structure, which account for roughly 70% of gross annual premiums and about 80% of the value of total assets in the UK's property-casualty insurance sector over the period of analysis.

4.2. Loss reserve error proxies

Ideally, reserve errors are measured by taking the difference of the originally obtained reserve (i.e., outstanding claims + IBNR) losses) and the fully developed reserve (i.e., the sum of all claim payments associated with that reserve). However, this estimation procedure is often impractical because of the lack of complete and accurate loss development data (Grace and Leverty, 2010, 2012). Accordingly, prior studies employ one of two main methods for calculating reserve errors. The Weiss (1985) method is the difference between the estimated incurred value of losses reported in $year_t$ (including IBNR), and the cumulative *actual* amount of loss development settled in the future accounting period $year_{t+n}$. That is:

$$Weiss_{i,t} = Incurred\ Losses_{i,t} - Developed\ Losses\ Paid_{i,t+n}. \quad (1)$$

The *KFS* approach is the difference between the estimated value of incurred losses reported in $year_t$ (including IBNR), and a re-estimate of these incurred losses given *n* years of loss development (e.g., in $year_{t+n}$) (Kazenski, Feldhaus, and Schneider, 1992), namely:

$$KFS_{i,t} = Incurred\ Losses_{i,t} - Incurred\ Losses_{i,t+n}. \quad (2)$$

In estimating reserve errors, it is desirable for *n* to be as large as possible (Petroni, 1992). UK regulatory filings require property-casualty insurers to disclose, for the current and nine preceding loss development years, the original reserve, the reserve as re-estimated in each following year, and the cumulative amount paid against the reserve in each subsequent year. Thus, the largest possible *n* is nine years. Although 'large' *n* generally results in more accurate loss reserves, it can nevertheless significantly reduce the final dataset (by the latest nine years). Therefore, the objective is to choose *n* that is sufficient to detect statistically significant reserve errors within a sample of insurers without unduly limiting the sample size. Following Grace and Leverty (2012), we use the five most recent accident years (*t-4*, …, *t*) to estimate the incurred losses ($Incurred\ Losses_{i,t}$) for *KFS* and *Weiss* errors. The five most recent accident years capture the greater part of calendar year reserves, with loss reserves for years *t-5* to *t-9* generally forming a small part of total reserves. In addition, a five years' period for unexpired risks is used to examine the magnitude of loss reserving errors ($Incurred\ Losses_{i,t+5}$ and $Developed\ Losses\ Paid_{i,t+5}$).

4.3. *Modeling procedure*

To test the relation between leverage and the direction (sign) of loss reserving errors (H1A and H1B), we first estimate fixed-effects logistic regressions of the general form:

$$ln\frac{\pi_{it}}{1-\pi_{it}} = \beta Incentives_{it} + \gamma Controls_{it} + u_{it}, \quad (3)$$

where subscript *i* denotes i^{th} insurer (*i* = 1, … , 151) and subscript *t* denotes the t^{th} year (*t* = 1991, … , 2005). $\ln(\pi_{it}/1-\pi_{it})$ is the logit dependent variable representing (*KFS/Weiss*) loss reserve errors. To test the likelihood of under-reserving in highly levered insurance firms, as predicted by H1A, the dependent variable in equation (3) takes the value of 1 if the error is under-reserved (negative), and 0 otherwise; *Incentives* is a vector of the main explanatory variables (i.e., leverage, reinsurance, growth, proportional reinsurance, and derivatives plus relevant interactions); and *Controls* is a vector of firm-specific variables that could affect insurers' reserving decisions (i.e., return on assets (plus its standard deviation), tax shield, product mix, group membership, public listing, age and firm size). All the variables that enter our analysis are defined and briefly motivated in section 4.4 below. The disturbance term in equation (3) is specified as a two-way error component model of the form:

$$u_{it} = \mu_i + \lambda_t + \nu_{it} \quad (4)$$

where μ_i denotes an insurer-specific effects, λ_t denotes year-specific effects and ν_{it} denotes the remaining disturbance. The results from estimating equation (3) are reported in Tables 3 and 4, and examined in section 5.2.

Second, to investigate the empirical relation between leverage and the level of over/under reserve errors, including the conjoint-effect of reinsurance and premium growth (H2), we first estimate the following model:

$$Error_{it} = \alpha_{it} + \varphi Error_{i,t-1} + \beta Incentives_{it} + \gamma Controls_{it} + u_{it}, \quad (5)$$

where $Error_{it}$ represents our dependent variables (*KFS or Weiss* errors) scaled by total assets. The vectors of *Incentives* and *Controls* consist of those explanatory variables noted above with reference to equation (3). However, reserve errors in a given period could be influenced by the previous year's reserving decisions thereby creating a potential endogeneity issue with regard to persistency in the dependent variable, $Error_{it}$. Accordingly, and as recommended in Arellano and Bond (1991), the GMM estimator can be employed with a single-period lagged dependent variable ($Error_{i,\ t-1}$) entering the analysis as an explanatory variable that is correlated with μ_i. To mitigate potential bias, Arellano and Bond (1991) also propose that to control for unobserved firm-level influences (e.g., different in risk management expertise) firm-specific fixed-effects are eliminated by taking the first-difference of equation (5). That is:

$$\Delta Error_{it} = \alpha_{it} + \varphi \Delta Error_{i,t-1} + \beta \Delta Incentives_{it} + \gamma \Delta Controls_{it} + \Delta u_{it}, \tag{6}$$

where,

$$\begin{gathered} \Delta u_{it} = (\mu_i - \mu_i) + (\lambda_t - \lambda_{t-1}) + (\nu_{it} - \nu_{i,t-1}). \\ \Delta u_{it} = \Delta\lambda_t + \Delta\nu_{it}. \end{gathered} \tag{7}$$

Though fixed-effects (μ_i) are eliminated by first-differencing, $Error_{i,t-1}$ is still potentially endogenous as *$Error_{i,t-1}$* in $\Delta Error_{i,t-1} = Error_{i,t-1} - Error_{i,t-2}$ is correlated with $\nu_{i,t-1}$in $\Delta\nu_{it} = \nu_{it} - \nu_{i,t-1}$. However, this can be resolved using lagged values of the explanatory variables in levels as instruments in the difference equation (Hsiao,2003). For example, valid instruments for $(Error_{i,t-1} - Error_{i,t-2})$ are the lagged levels $Error_{i,t-2}, Error_{i,t-3}, \ \ldots, Error_{i,t-j}$, as $E\left[Error_{i,t-j}\left(\nu_{it} - \nu_{i,t-1}\right)\right] = 0$, as long as $j \geq 2$ and ν_{it} are not serially correlated. Two additional problems can nonetheless arise from estimating equation (5) by differencing. First, the 'cross-insurer' dimension of the data is lost because it does not vary with time. Second, if the dependent variable in equation (5) is persistent over time, then the lagged value is a potentially weak instrument for the differenced equation, thereby, producing biased estimates (Baltagi,2005). Therefore, we use the *GMM-SYS* method of Arellano and Bover (1995), with a 'collapsed matrix' of lagged instruments as recommended in Roodman (2009), to estimate equation (6).

Wintoki, Linck and Netter (2012) note that in contrast to other panel data methods, such as two-stage least squares (*2SLS*), *GMM-SYS* does not rely on external instrumental variables, which are often difficult to identify and justify in accounting and finance research. *GMM-SYS* also assumes that omitted variables are time-invariant (which is likely in short panels such as that employed in the present study). In addition, *GMM-SYS* allows indicator variables (e.g., *Group* and *Public*) to enter the analysis. Veprauskaite and Adams (2013) note that with *GMM-SYS*, instrument validity can be tested by the Sargan-Hansen *J*-test of over-identifying restrictions, which is asymptotically distributed as $\chi^2(n)$ with n degrees of freedom under the null hypothesis that selected instruments ae valid. The Difference Sagan-Hansen test is used to check the exogeneity of the regressors, while the Arellano-Bond z-statistic can be used to test for first-order (AR1) and second-order (AR2) autocorrelation in the residuals. First-order autocorrelation is not an important issue in first-difference estimations, whereas second-order autocorrelation could affect the reliability of derived parameter estimates. In the present study, all diagnostic tests supported the null hypotheses, indicating that the results derived from the *GMM-SYS* procedure are reliable. The estimates derived from equation (6) are reported in Tables 5 and 6, and analysed in section 5.2. *GMM-SYS* diagnostics are also reported in Tables 5 and 6.

To test the effect of reinsurance on the accuracy of loss reserves as predicted by H3 and H4, we employ equation (8) below to separate the frequency distribution of positive and negative errors:

$$\begin{aligned} Abs(Error)_{it} &= \alpha_{it} + \varphi Abs(Error_{i,t-1}) \\ &+ Over\text{--}\,Reserve_{it}(\beta_O Incentives_{it} + \gamma_O Controls_{it}) \\ &+ Under\text{--}\text{-}Reserve_{it}(\beta_U Incentives_{it} + \gamma_U Controls_{it}) + u_{it}, \end{aligned} \tag{8}$$

where *Abs(Error$_{it}$)* is the absolute value of the *KFS* or *Weiss* loss reserve error estimates, scaled by total assets. *Over-Reserve* and *Under-Reserve* are dummy variables, indicating the direction of the error (e.g., *Over-Reserve* is equal to 1 and *Under-Reserve* is equal to 0 if reserve-error is positive). Subscripts *O/U* denote coefficient estimates if reserve-errors are positive/negative. The vectors of explanatory variables classified as *Incentives* and *Controls* are as noted previously. The results from estimating equation (8) using the *GMM-SYS* estimator are reported in Tables 7 and 8 (together with the *GMM-SYS* diagnostics), and again evaluated in section 5.2 below.

4.4. Variable definitions

4.4.1. *Main explanatory variables*

Leverage (Solvency): The introduction of 'individual risk-based capital assessment' in the UK following the FSMA (2000), precluded the use of regulatory-based solvency thresholds to motivate insurers' ex-ante loss reserving practices as noted in earlier US studies, such as Petroni (1992) and Beaver et al. (2003). To approximate an insurer’s leverage (solvency) risk, and assess its impact on loss reserves (H1A and H1B), we follow Ho, Lai, and Lee (2013) and use the standard regulatory leverage ratio:

$$Leverage(1)_{i,t} = 1 - \frac{Surplus_{i,t}}{Total\ Assets_{i,t}}, \tag{9}$$

where *Surplus* is the sum of capital and shareholders' funds and *Total Assets* are tangible fixed and current (so-called 'admissible') assets of an insurer that are used by the UK insurance industry regulator to assess annual statutory minimum levels of solvency. The larger *Leverage(1)*, the greater an insurer's insolvency risk. We also employ an alternative measure of insurers' solvency risk – *Leverage(2)*, namely, the ratio of net premium written to surplus at year-end (Eden and Kahane, 1988). *Leverage(2)* measures the ability of insurer to absorb above-average losses; the greater an insurer's leverage (insolvency risk), the higher the *Leverage(2)*. To account for possible non-linear leverage effects on reserve errors, squared values of our leverage measures also enter the analysis.

Reinsurance: Highly reinsured insurers are likely to be subjected to tighter control and monitoring by their reinsurance partners (Plantin, 2006). Therefore, we predict that *Reinsurance* will have a negative relation with respect to the size of loss reserve errors (H3). As in Adiel (1996), the level of reinsurance is measured as:

$$Reinsurance_{i,t} = \frac{Ceded\ Premium\ Written_{i,t}}{Gross\ Premium\ Written_{i,t}}. \tag{10}$$

Growth: As in Grace and Leverty (2010), *Growth* is measured as the ratio of annual increase in net premiums written. We normalise the *Reinsurance* and *Growth* variables to reduce potential multicollinearity[8].

Proportional Reinsurance: This is defined as:

$$Proportional_{i,t} = \frac{Ceded\ Premium\ \ under\ Proportional\ Reinsurance_{i,t}}{Total\ Reinsurance\ Premium\ Ceded_{i,t}}. \tag{11}$$

Proportional reinsurance helps primary insurers minimize information asymmetries at the point of sale by sharing with third party reinsurers a proportion of the expected value of the loss distributions of risks underwritten. In contrast, non-proportional reinsurance helps reduce variance uncertainty only in the extreme tail of the expected loss distribution of insurance business (Eden and Kahane,1988). This makes setting reserves for retained low frequency but high magnitude losses difficult for insurance managers (actuaries) to establish with precision when non-proportional reinsurance predominates – as it often does in 'long-tail' lines of insurance, such as legal liability. As a result, we expect *Proportional* to be negatively related to the size of reserving errors (H4).

Rein x Growth: As noted earlier, Harrington and Danzon (1994) suggest that managers of high premium 'growth opportunity' insurers can increase underwriting capacity, lower liquidity problems arising from 'new business strain', and alleviate the risk of insolvency resulting from new business growth by purchasing reinsurance, and thereby, reducing leverage (improving solvency). Therefore, as in H2, we predict that highly leveraged insurers experiencing new business growth will purchase more reinsurance, and so reduce loss reserves. As such, we include (mean-centred) interaction terms in our estimations to capture the conjoint-effects of reinsurance and premium growth on loss reserves[9].

4.4.2. *Other treatment effects*

Reinsurance can substitute for other risk management techniques, notably the use of derivatives instruments (Shiu, 2011). Therefore, we introduce two variables into our regression analysis to control for the effects of derivatives usage on loss reserving as follows:

Derivatives: Smith and Stulz (1985) find that the use of financial derivatives (i.e., forwards, futures, options and swaps) reduces the variability of the future value of the firm, and so lowers the probability of incurring costs related to insolvency risk. Thus, all else equal, insurers that engage in derivatives hedging are expected to have lower incentives to manage their loss reserves. Following Shiu (2011), our *Derivatives* variable is labeled 1 for a derivative user, and 0 otherwise.

Rein x Deriv: Insurers can use both reinsurance and derivatives to manage their business risks (Shiu, 2011). We expect the interaction between reinsurance and derivatives lowers the volatility of insurers' earnings, and so reduces the motives for insurers to manage their loss reserves to smooth their reported performance. Therefore, we introduce an interaction term between *Reinsurance* and *Derivatives*, which is normalised to reduce possible multicollinearity.

4.5. Firm-specific controls

As in previous studies (e.g., Petroni, 1992; Grace and Leverty, 2010, 2012), we also control for key firm-related variables that can impact on the reserving decisions of insurance firms. The firm-related variables that enter our analysis are briefly outlined and motivated below.

Petroni, Ryan and Wahlen (2000) find the greater (lower) past average returns on assets (*ROA*), the greater the management incentives to smooth period income by over (under) estimating reserves in order to minimize potentially costly scrutiny by regulators, and others. ROA is defined as annual earnings before interest and tax (EBIT) divided by the book value of total assets. Consistent with prior research (e.g.,Grace, 1990), we measure income smoothing as the average ROA over the past three years. We anticipate that insurers with on average larger *ROA* over the past three years are likely to under-estimate loss reserves. In addition, increased variability in earnings could increase the incidence and magnitude of reserving errors. Therefore, we include the standard deviation of an insurer's ROA (*Std_ROA*) over the past five years as a control variable. Adiel (1996) reports that over-reserving can reduce (or postpone) period taxes (by reducing reported earnings), while under-reserving can have the opposite effect (by increasing reported earnings). Petroni and Shackelford (1999) note that in the US, insurers often shift premiums and losses across states and between accounting periods in order to reduce tax liabilities. Grace (1990) further argues that insurers inflate reserves for future losses as their taxable income increases. As a result, we expect *Tax Shield* to be positively related to over-reserving. As in Grace (1990), we measure *Tax Shield* as:

$$Tax\ Shield_{i,t} = \frac{(Net\ Income_{i,t} + Estimated\ Reserve_{i,t})}{Total\ Assets_{i,t}}. \tag{12}$$

Petroni and Beasley (1996) observe that insurers writing long-tail insurance (e.g., legal liability) tend to have greater reserving errors than other insurers. This is due to the difficulty of accurately estimating the probability, quantum, and timing of insurance claims. Therefore, a variable for insurer's participation in long-tailed lines of business (*Long-Tail*) enters our analysis, and is defined as the proportion of annual net (of reinsurance) premiums written on long-tail insurance to total annual net premiums written. Mayers and Smith (1990) suggest that, all else equal, insurers with a more diversified product mix are likely to be better able to diversify business risks and so less prone to reserve errors than more specialist insurers. Accordingly, a control variable representing an insurer's range of products (*Product Mix*) is included in our analysis. This variable is measured by a Herfindahl concentration index (equation 13) that is computed from the five main lines of insurance sold in the UK's property-casualty insurance market.[10]

$$Product\ Mix_{i,t} = \sum_{l=1}^{5} \left(\frac{DPW_{l,i,t}}{TPW_{i,t}}\right)^2, \tag{13}$$

where DPW_l is the amount of direct premium written in the l^{th} line of insurance and TPW is the amount of total premium written across property and liability lines by an insurer i in year t. The closer the Herfindahl index is to one, the more concentrated the production function of insurance firms implying a positive relation with the accuracy of loss reserves.

We identify organizational structure in our estimation using two variables. The first variable - *Group* - is a binary variable that equals 1 if an insurer is affiliated to a conglomerate group and 0 otherwise. Grace and Leverty (2012) argue that group insurers can draw on a 'deep pool' of actuarial and underwriting expertise in order to reduce the incidence of reserving error. This implies an inverse relation between group status and the magnitude of loss reserve errors. The second organizational structure variable - *Public* - is also a binary variable equal to 1 if an insurer is publicly quoted on a major stock market (e.g., London), and 0 otherwise. Public and private firms potentially face different demands for accounting information, with publicly quoted insurers likely to be associated with higher reporting quality (i.e., reduce loss reserve errors) in order to attract and assure market investors. The duration that an insurer has operated in the UK may also affect the accuracy of loss reserves. For example, well-established insurers are likely to have better loss experience data, and therefore, produce more accurate loss reserves. We define firm age (*Age*) as the natural logarithm of the number of years since an insurer was established in the UK. In addition, relative to large entities, small insurance firms are likely to be inefficient at diversifying risk and more prone to making reserving errors (e.g., because of an absence of in-house actuarial expertise). This implies an inverse relation between the accuracy of loss reserves (per unit of insurance) and firm size. To avoid possible co-linearity between *Firm Size* and *Product mix*, we use the residual of firm size (*Residual of Size*) in our main analysis. *Residual of Size* is measured by standardized residuals obtained by regressing *Firm Size* with *Product Mix*.

5. Empirical results

5.1. Summary statistics

Table 1 provides summary descriptive statistics for the variables used in our study. Table 1 indicates that the mean loss reserve is over-estimated by 1.4% of total assets according to the *KFS* error and 2% with the *Weiss* error, indicating that on average, the insurers in our dataset tended to over-reserve between 1991 and 2005. In Table 1, the mean of *Leverage(1)* is 0.703, indicating that on average, the value of insurers' total claims liabilities are about 70% of total assets. The mean *Leverage(2)* ratio is 1.5, showing that for the average insurer net premiums written exceed capital and surplus by 150%. On average, our sample of UK insurers cede just over a quarter of their annual gross premiums to reinsurance firms (*Reinsurance*), while only around 12% of our sample insurers use derivatives due to regulatory controls that seek to prevent speculation and ensure continued solvency (*Derivatives*). Proportional reinsurance, at an average of approximately 11% of total reinsurance ceded, is small compared with the use of non-proportional reinsurance. This indicates the relative importance of non-proportional reinsurance in covering tail-end losses and maintaining underwriting capacity and financial viability in property-casualty insurance (Weiss and Chung, 2004). More than 25% of our panel sample observations have policies written in a single line of insurance business (*Product Mix* = 1). Over 88% of the insurers in our data set are affiliated with a corporate group, and approximately 13% are publicly listed on a major stock exchange, such as London. The mean (median) age of insurer in the sample is 43 years (34 years). The average company size in terms of total assets held is £633 million. However, the median total assets size is significantly lower (i.e., £90.7 million), showing that the sample is skewed towards larger insurance firms (with the largest insurer in the panel sample reporting total assets of approximately £4.5 billion in 2005).

[Insert Table 1 here]

Table 2 gives the means and standard deviations for reserve errors (*KFS and Weiss* scaled by total assets) broken down by the levels of the key explanatory variables. Table 2 also reports the *F*-statistics of the one-way analysis of variance (ANOVA) F-test and χ^2-statistics of Kruskal-Wallis test. We find only modest statistical evidence (p≤ 0.10, two-tailed) that average loss reserving errors differ across different quartiles of *Leverage(1)*. We further note that insurer-year observations with the highest *Leverage(1)* value (1 - surplus-to-asset ratio) (4th quartile) have on average smallest loss reserve errors. However, the standard deviation of reserve errors in the highest quartile of *Leverage(1)* is large indicating that some high-leverage insurers over-reserve, while others under-reserve their claims liabilities. The χ^2 statistics given in Table 2 also show that insurers with the highest and the lowest *Leverage(2)* (Q1 and Q4) have on average smallest reserving errors. Therefore, to gain better insights on the relation between insurers' leverage risk and reserve errors, regressions that distinguish the relative magnitude of positive and negative reserve errors are performed, and reported in Tables 5 and 6. Additionally, both the *F*-statistics and χ^2 statistics given in Table 2 indicate that the mean reserve errors significantly differ across quartiles of the *Reinsurance* distribution.

[Insert Table 2 here]

5.2. Multivariate analysis

Tables 3 and 4 relate to H1A and H1B and show the results of the fixed-effects logistic regression analysis (equation (3)) with regard to the direction (sign) of (*KFS/Weiss*) reserving errors with respect to leverage. As the fixed-effects logistic model requires the dependent variable to be time variant, insurers that continuously over-reserved or under-reserved in every year during the period of analysis were eliminated in our multivariate tests. This gives a final sample of 1,034 firm-year observations (n = 108 insurance firms) for *KFS* errors and 964 firm-year observations (n=103 insurance firms) for *Weiss* errors.

Consistent with H1A (and with the logistic dependent variable in equation 3 set to 1 in cases of under-reserving, and 0 otherwise), the positive estimated coefficients reported in Tables 3 and 4 indicate that insurers with higher leverage (as measured by 1-suplus/asset ratio (*Leverage(1)*) and/or premium/surplus ratio (*Leverage(2)*) are more likely to under-estimate their loss reserves (at p<0.10, two-tailed). However, in practical terms the under-estimate only amounts to about 1% of the book value of reserves[11]. However, the statistically significant (at p<0.10, two-tailed), but negatively signed coefficient estimates for the squared leverage proxies in Tables 3 and 4 reveal that, as predicted by H1B, when leverage levels get close to breaching statutory minimum levels of solvency, insurers will over-reserve in anticipation of, or in response to, regulatory enforcement notices. This is a novel finding and suggests that the managers of UK insurance firms are likely to be mindful of preventing regulatory intervention and the probability of ruin. In line with H2, we further find that highly reinsured/high premium growth insurers (*Rein x Growth*) are more likely to report low loss reserves (at $p<0.10$, two-tailed).

Turning to our firm-related control variables, we obtain statistically significant (at $p<0.01$, two-tailed) and positive coefficient estimates with regard to the growth in the three-year average *ROA*, leading to a greater likelihood of under-reserving. This suggests that the bigger average past levels of *ROA*, the more managers are motivated to under-reserve in order to meet financial (e.g., earnings) targets (at $p<0.05$, two-tailed). We also find evidence (at $p<0.01$, two-tailed) that insurers with more variable past performance (*Std_ROA*) and higher taxable income (*Tax Shield*) are more likely to over-reserve - for example, to mitigate the potential liquidity constraints arising from increased market volatility.

[Insert Tables 3 & 4 here]

To examine the effects of insurers' leverage on the level of over/under-reserving errors implied by H1A and H1B, we estimate a *GMM-SYS* model (equation 6) with the dependent variables *KFS* and *Weiss* errors scaled by total assets. The results are given in Tables 5 and 6, with the appropriate diagnostics (e.g., Hansen's (1982) *J*-test), also conducted.

[Insert Tables 5 & 6 here]

Tables 5 and 6 demonstrate that the coefficient estimates for the lagged dependent variable are positive and statistically significant ($p < 0.01$, two-tailed), in the *KFS* and *Weiss* error regressions. This observation accords with the study of Beaver and McNichols (1998), and suggests that reserve errors are positively influenced by the previous year's reserving decisions. The coefficient estimates for both of our leverage measures (*Leverage(1)* and *Leverage(2)* are negative in levels, and positive in the squared transformations with both *KFS* and *Weiss* reserve errors (at $p<0.10$, or lower, two-tailed). These results further suggest that as leverage increases, insurers tend to under-reserve their liabilities as demonstrated in prior US research (e.g., Petroni, 1992). However, when the ratio of claims liabilities to total assets exceeds about 90%, and so threatens statutory solvency targets, insurers will over-reserve. From Tables 5 and 6, we also observe a negative, but statistically significant relation between *Rein x Growth* and reserving errors (at $p< 0.10$, two-tailed). Again consistent with H2, this result implies that insurers generating high premiums under-reserve and purchase reinsurance to limit the risk of unexpectedly high claims arising from a rapid growth in new business.

Next, we employ equation 8 to test H3 and H4 on the relation between reinsurance and the accuracy of reserves. The coefficient estimates for the absolute magnitude of the *KFS* reserve error are shown in Table 7, with the corresponding results for the *Weiss* reserve error given in Table 8. Positive coefficient estimates indicate large loss reserve errors, while negative estimates reflect smaller errors.

[Insert Tables 7 & 8 here]

Tables 7 and 8 show that the coefficient estimates for *Leverage(1)* are generally positive and statistically significant, implying a propensity for highly levered insurers to greatly under-estimate loss reserves (at $p \leq 0.10$, or two-tailed). In contrast, the coefficient estimates for the squared form of *Leverage(1)* are generally negative and significant, suggesting less of a tendency to substantially under-state loss reserves (at $p \leq 0.05$, two-tailed). These observations for *Leverage(1)* accord with H1A and H1B though the comparative results for *Leverage(2)* are less clear cut. The coefficient estimate for the interaction term *Rein x Growth* is positive and statistically significant with negative (smaller) *KFS and Weiss* errors (at $p \leq 0.05$, two-tailed), in line with H2.

The estimated coefficients for *Reinsurance* are negative and statistically significant with positive (large) reserving errors in all *KFS* and *Weiss* regressions presented in Tables 7 and 8 (at $p < 0.10$ or better, two-tailed). These results support H3, and the view that highly reinsured insurers have a lower incidence of reserving errors than insurers that purchase less reinsurance. Prior research (e.g., Browne et al., 2012) suggests that more accurate loss reserves result from a reduction in information asymmetries. In mitigating market imperfections, reinsurers can play an important role as effective monitors of primary insurers' financial and risk management systems. Furthermore, reinsurance enables primary insurers to retain smaller and more predictable risks and reinsure larger, but less predictable exposures as well as benefit from the risk management advice of reinsurance partners (Browne et al., 2012). These attributes help reduce the uncertainty of future claims liabilities, and enable insurers to more accurately estimate loss reserves. However, the results in Tables 7 and 8 indicate that contrary to H4, the use of proportional reinsurance by UK insurers does not significantly affect reserving accuracy. This could, however, reflect the lower incidence of proportional risk reinsurance treaties in property-casualty insurance compared with the life insurance sector (e.g., see Winton, 1995).

In subsidiary tests, we also investigate the potential substitutive effect of derivatives use on loss reserving errors. However, none of the coefficient estimates for *Derivatives* are statistically significant. Additionally, in all regressions, the coefficient estimates for the interaction term *Rein x*

Deriv are not statistically significant, suggesting that as a risk management tool only reinsurance is effective in reducing reserving errors. Indeed, and as we noted earlier, in order to minimise the risk of financial distress and/or bankruptcy the use of derivatives by UK insurance firms is also strictly controlled by regulation.

Consistent with prior US-based research (e.g., Grace, 1990; Petroni, 1992; Beaver and McNichols, 1998), Tables 7 and 8 indicate that *ROA* is positive and statistically significant with under-reserving errors, and negative and significant with over-reserving errors (at $p \leq 0.10$, two tailed) in the *KFS* and *Weiss error* analyses. These results imply that insurers with higher than average ROA over the past three years, under-state loss reserves. Additionally, *Std_ROA* is also positively related to over-estimated loss reserves. This accords with our expectation that volatile business performance increases uncertainty of future losses, and therefore, results in large reserving errors. The coefficient estimates for *Tax Shield* are negatively significant (at $p \leq 0.10$, two-tailed), indicating that UK insurers with on average higher taxable income tend to have a low degree of under-reserving error.

All our regression models control for pre-defined firm-specific variables and time-effects. In summary, Tables 7 and 8 indicate that insurers operating within group structures (*Group*) are more likely to under-reserve than insurers that are not members of a corporate group. A possible explanation for this observation is that conglomerate insurers have better access to internal and external sources of capital, which enable them to under-estimate reserves without generating regulatory concern. As expected, we find that public insurers (*Public*) and insurers operating longer in the UK market (*Age*) more accurately estimate their loss reserves - for example, due to their greater risk management expertise and longer loss experience records. Additionally, bigger and more product-diversified insurers tend to have less reserving errors than smaller and niche product insurers. This suggests that larger diversified insurers can afford investing in the risk management expertise necessary to reduce the incidence and magnitude of reserving errors across their underwriting portfolios. Finally, our results show that insurers specialising in long-tail business (*Long-Tail*) (e.g., legal liability) have smaller positive errors than insurers that write shorter-tail insurance business. This finding is inconsistent with our expectations and prior US findings; but it might suggest that long-tail insurance providers have segment-specific risk knowledge that helps them to mitigate loss reserve errors to a greater extent than insurers that write mainly short-tail (e.g., motor) insurance business.

6. Conclusions

Using 1991 to 2005 firm-level panel data drawn from the UK's property-casualty insurance industry, this study examines the relation between loss reserving errors, insurers' leverage and reinsurance. We find that insurers with poor financial performance under-estimate reserves to potentially reduce leverage, and so pre-empt costly regulatory scrutiny. However, when leverage levels reach very high levels (i.e., where the value of claims to total assets exceeds about 90%), insurers over-reserve for future liabilities, indicating for the first time a non-linear relation between leverage and reserving policy. This suggests that the managers of insurance firms treat precautionary reserving as a high priority strategic issue in the face of potentially large and uncertain future losses, and costly regulatory intervention. In this regard, our results provide some comfort to policyholders, industry regulators, and others (e.g., credit ratings agencies) that have a direct interest in monitoring the adequacy of solvency management in UK insurance firms - an attribute is likely to be particularly important under the 2016 capital rules for European insurers - Solvency II.

We also investigate whether monitoring by reinsurers reduces reserving errors in highly reinsured insurers and find that consistent with prior research (e.g., Adiel, 1996), heavily reinsured insurers are less likely to manipulate loss reserves. This observation suggests that reinsurers play important monitoring and advisory roles in influencing solvency and other financial policies (e.g., earnings management) of primary insurers - a commercial and policy function that helps underpin the maintenance of statutory minimum levels of solvency, and facilitate effective regulatory control. However, we do not find evidence to support the view that insurers that predominantly use proportional reinsurance report more accurate reserving errors. Further, we do not find that derivatives hedging affects the accuracy of loss reserves. Finally, by contributing new insights into the inter-relation between strategic risk management decisions (e.g., reinsurance) and discretionary accounting accruals, the present study could help scholars, accounting standard-setters, insurance industry regulators, and others to conduct financial analyses in other industrial contexts.

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Notes

[1] Purnanandam's (2008) suggests that the risk to investors of financial distress/bankruptcy increases when corporate debt-to-asset ratios reach about 90% - i.e., 'at very high' leverage levels. Our analysis also indicated that across all lines of insurance business examined, over-reserving tended to increase when claims-to-asset ratios reached the 90% threshold.

[2] The insurance underwriting cycle begins after periods of large losses when premium rates rise thereby increasing profits, and attracting inflows of capital into the property-casualty insurance sector. Thereafter, excess capital induces price cutting in competitive insurance markets (Cummins and Danzon, 1997).

[3] From 1 April 2013 the statutory supervision and regulation of UK insurers has been conducted by the Prudential Regulation Authority (PRA), whilst matters of insurance market operations are regulated by the Financial Conduct Authority (FCA). The PRA is part of the Bank of England, and the FCA is an independent regulatory body which is accountable to HM Treasury.

[4] Unlike US insurers, which report using generally accepted insurance accounting principles (US GAAP), major UK insurance firms have since January 2005 reported their business activities in line with, International Financial Reporting Standard (IFRS) 4, which established changes in the accounting and financial reporting rules for UK and other European publicly listed insurers, including disclosure of reserve movements. However, IFRS 4 was only applicable towards the tail-end of our analysis period (1991 to 2005), and unlikely to significantly affect our analysis. Also, since 1 January 2015 non-publicly listed UK (and Irish) insurers report under accounting standard FRS 103 - a standard that is largely consistent with IFRS 4.

[5] Public media sources are replete with reports that the UK insurance regulator has concerns about the release of prior years' reserves to meet short-term profit and dividend targets. For example, see the Financial Times article of 14 November, 2014, 'Regulators to probe insurers over drawing down reserves'. Such regulatory unease often results in UK insurers being compelled to make reserve additions in order to meet statutory solvency targets and ease regulatory concerns about their future financial condition.

[6] The under-investment incentive is an agency cost of debt problem that relates to the risk, particularly in highly leveraged states, that shareholders may not reinstate productive assets following a severe loss event as the gains from reinstatement accrue to debtholders rather than themselves. In such a situation, shareholders may exercise their ‘default' put option under limited liability and voluntarily liquidate the firm. However, Garven and MacMinn (1993) note that the under-investment problem can be mitigated by (re)insurance contracts in that the proceeds from (re)insurance claims can be used to reinstate impaired assets after unexpectedly severe losses, thereby, minimizing the risks (and costs) of financial distress and/or bankruptcy.

[7] Although proportional and non-proportional treaties are used across property and liability lines of business, non-proportional treaties are commonly used in catastrophe and liability lines of insurance (Winton, 1995). However, we control for the possibility that choice of reinsurance treaty could be driven by line of business in our regression analyses.

[8] To further test for multicollinearity we compute variance inflation factors (VIFs) for our independent variables. All VIF values are well below the benchmark value of 10, with the largest being 2.46 (e.g., see Kennedy, 2003). Therefore, bias due to multicollinearity is unlikely to be problematic in this study.

[9]Ai and Norton (2003) note that interpreting coefficient estimates on interactions can be problematic, especially in non-linear (e.g., logistic) specifications, unless the mediating effect is estimated using consistent cross-differences that account for all model covariates. We thus used the standard cross-partial derivatives estimator to deal with this issue.

[10] The five main lines of business written in the UK's property-casualty insurance market are: personal accident & health, motor, property, legal liability, and miscellaneous & pecuniary insurance.

[11] This percentage is derived from multiplying the standard deviations for the KFS and Weiss under-reserving errors in Table 1 with the relevant coefficient estimates in Tables 3 and 4.

TABLE 1

Descriptive Statistics, UK Property-Casualty Insurers, 1991-2005

Variable	Mean	Median	Std. Dev.	1st Quart.	3rd Quart.	Obs.
KFS	0.014	0.009	0.085	-0.004	0.047	1386
KFS (O)	0.044	0.027	0.047	0.008	0.067	959
KFS (U)	-0.056	-0.023	0.107	-0.061	-0.006	427
Weiss	0.020	0.012	0.082	-0.001	0.052	1386
Weiss (O)	0.047	0.028	0.052	0.008	0.072	1017
Weiss (U)	-0.059	-0.023	0.111	-0.060	-0.007	369
Leverage(1)	0.703	0.748	0.175	0.605	0.829	1386
Leverage(2)	1.535	1.378	1.123	0.623	2.201	1386
Reinsurance	0.259	0.176	0.249	0.059	0.404	1386
Proportional	0.111	0.100	0.054	0.011	0.010	1386
Derivatives	0.120	0.000	0.326	0.000	0.000	1386
Growth	0.174	0.055	1.022	-0.072	0.224	1386
ROA	0.057	0.038	0.126	0.003	0.093	1386
Std_ROA	0.108	0.043	0.760	0.025	0.078	1386
Tax Shield	0.344	0.222	0.978	0.118	0.339	1386
Long-Tail	0.107	0.008	0.203	0.000	0.111	1386
Product Mix	0.651	0.606	0.286	0.384	1.000	1386
Group	0.881	1.000	0.324	1.000	1.000	1386
Public	0.128	0.000	0.335	0.000	0.000	1386
Age	43.404	34.000	34.580	13.000	68.000	1386
Total Assets (mln. £)	633.323	90.676	1,665.047	230.030	439.705	1386

This table reports the summary statistics for the years 1991 to 2005. *KFS* error is defined as the difference between the incurred losses in the current period and a revised estimate five years in the future. *Weiss* error is the difference between the incurred losses in the current period and the developed losses paid five years in the future. Both errors are scaled by total assets. Positive (*O*) reserve errors indicate that the insurer initially over-reserved, while negative reserve errors (*U*) indicate under-reserving. Leverage(1) is 1 - surplus-to-asset ratio; *Leverage(2)* is a net premium-to-surplus ratio; *Reinsurance* is the ratio of gross premium written ceded to reinsurer; *Proportional* – proportion of gross premium ceded under proportional reinsurance cover; *Derivatives* = 1 for a derivative user (i.e., an insurer has non-zero year-end derivative position or if derivatives are open at the end of the previous year) and 0 for a nonuser; *Growth* is the ratio one-year increase in net premium written; *Long-Tail* is the ratio of losses incurred in long-tail lines of insurance; *ROA* is measured as average returns on assets over the period of past three years; *Std_ROA* is measured as standard deviation of ROA over the period of past five years; *Tax Shield* is the sum of net income and estimated reserves divided by the total admitted assets; *Product Mix* is the line of business Herfindahl index, which measures an insurer's product diversification; *Long-Tail* is defined as the share of annual net premiums written on liability insurance to total annual premiums written; *Group* is an indicator variable for insurers that are associated with a group; *Public* is dummy variable equal to 1 if an insurer is publically quoted and 0 otherwise; *Age* is the natural log of the number of years since the insurance firm was established in the UK.

TABLE 2

Comparison of KFS and Weiss Reserve Errors by the Levels of Hypothesised Variables, UK Property-Casualty Insurers, 1991-2005

Group Variable	On	KFS				Weiss			
		Mean	S.D..	F-test	χ^2-test	Mean	S.D.	F-test	χ^2-test
Leverage(1): Q1	347	0.014	0.060			0.019	0.066		
Leverage(1): Q2	346	0.013	0.067			0.018	0.064		
Leverage(1): Q3	347	0.022	0.075			0.028	0.076		
Leverage(1): Q4	346	0.005	0.123	20.35 *	40.39	0.015	0.11310.66		60.9*
Leverage(2): Q1	346	0.008	0.073			0.016	0.073		
Leverage(2): Q2	347	0.017	0.075			0.023	0.075		
Leverage(2): Q3	346	0.018	0.104			0.025	0.097		
Leverage(2): Q4	347	0.011	0.084	1.11	18.3***	0.017	0.08210.00		17.1***
Reinsurance: Q1	346	0.023	0.067			0.027	0.072		
Reinsurance: Q2	347	0.021	0.087			0.028	0.088		
Reinsurance: Q3	346	0.012	0.089			0.019	0.083		
Reinsurance: Q4	347	-0.001	0.093	50.97***	13.26***	0.006	0.08350.40***		15.6***
Proportional: > 0	344	0.011	0.076			0.018	0.076		
Proportional: = 0	1042	0.015	0.088	00.57	00.64	0.021	0.08400.43		00.00
Derivatives: = 1	167	0.024	0.054			0.031	0.057		
Derivatives: = 0	1219	0.012	0.088	0.13 *	10.2***	0.019	0.085	3.28*	12.59***
Rein x Growth: Q1	346	0.002	0.094			0.011	0.091		
Rein x Growth: Q2	347	0.021	0.071			0.026	0.070		
Rein x Growth: Q3	346	0.019	0.090			0.026	0.084		
Rein x Growth: Q4	347	0.012	0.082	30.53 **	11.8***	0.018	0.08120.75**		10.7**

This table reports the means and standard deviations of *KFS* and *Weiss* errors (scaled by total assets) broken down by the levels of the main explanatory variables. *Leverage(1)* is 1 - surplus-to-asset ratio; *Leverage* is a net premium-to-surplus ratio; *Reinsurance* is the ratio of gross premium written ceded to reinsurer; *Proportional* – proportion of gross premium ceded under proportional reinsurance cover; *Derivatives* = 1 for a derivative user (i.e., an insurer has non-zero year-end derivative position or if derivatives are open at the end of the previous year) and 0 for a non-user; *Rein x Growth* is an interaction term between *Reinsurance* and *Growth*; *Growth* is the ratio one-year increase in net premium written. Q1-Q4 represents 1st - 4th quartiles of the distribution. The *F*-statistics of the one-way analysis of variance (ANOVA) and χ^2-statistics of the Kruskal-Wallis test are used to examine whether the means of loss reserve errors differ significantly across levels of leverage and reinsurance in two-tailed tests.

TABLE 3

Logistic Regression of Discretionary Reserving Behaviour in UK Property-Casualty Insurance Market 1991 to 2005: Leverage - Sign of KFS Reserve Errors

	(1)		(2)		(3)	
Variable	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Leverage(1)	2.662*	1.481	2.730*	0.165	-	-
Leverage(1)^2	-2.473*	1.489	-2.531*	1.482		
Leverage(2)					0.069*	0.040
Leverage(2)^2					-0.012*	0.007
Reinsurance	-0.235	0.274	-0.211	0.277	-0.030	0.275
Derivatives	-0.144	0.227	-0.143	0.227	-0.109	0.227
Rein x Growth			0.351*	0.201		
Growth	0.019	0.056	0.016	0.064	0.008	0.056
ROA	1.875***	0.641	1.952***	0.662	2.090***	0.616
Std_ROA	-0.226**	0.094	-0.223**	0.100	-0.239**	0.094
Tax Shield	-0.620***	0.214	-0.623***	0.216	-0.613***	0.214
Long-Tail	0.145	0.305	0.137	0.305	0.204	0.305
Product Mix	0.161	0.245	0.182	0.245	0.152	0.238
Public	-0.886***	0.222	-0.866***	0.220	-0.882***	0.221
Age	0.021	0.060	0.018	0.060	0.018	0.061
Resid_Size	-0.033	0.044	-0.036	0.044	-0.025	0.042
Time-effects	Yes		Yes		Yes	
Wald $\chi 2$	83.73***		133.32***		107.19	
Log L	-414.6		-413.3		-415.5	
No. of observations	1034		1034		1034	
No. of groups	108		108		108	

This table reports the results of the fixed-effects logistic (leverage/error direction) regressions (equations 3). The dependent variable is a dummy variable equal to 1 if *KFS* reserve error is negative, and 0 otherwise. All remaining variables are defined as in the text. Bootstrapped standard errors are reported. ***, **, and * indicate significance at the 0.01, 0.05, and 0.10 levels (two-tailed), respectively.

TABLE 4

Logistic Regression of Discretionary Reserving Behaviour in UK Property-Casualty Insurance Market 1991 to 2005: Leverage - Sign of Weiss Reserve Errors

	(1)		(2)		(3)	
Variable	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Leverage(1)	0.282*	0.101	0.407*	0.243		
Leverage(1)^2	-0.889 *	0.512	-1.009 *	0.535	0.126*	0.076
Leverage(2)					-0.075*	0.037
Leverage(2)^2						
Reinsurance	-0.389	0.283	-0.369	0.286	-0.027	0.030
Derivatives	-0.213	0.258	-0.211	0.258	-0.196	0.257
Rein x Growth			0.494*	0.302		
Growth	0.047	0.056	0.053	0.071	0.038	0.056
ROA	1.742***	0.624	1.820***	0.649	2.024***	0.627
Std_ROA	-0.174**	0.076	-0.167**	0.080	-0.178**	0.078
Tax Shield	-0.611***	0.208	-0.615***	0.210	-0.591***	0.206
Long-Tail	-0.232	0.333	-0.239	0.332	-0.131	0.337
Product Mix	0.601**	0.257	0.634**	0.258	0.542**	0.252
Public	-1.105***	0.261	-1.071***	0.257	-1.079***	0.260
Age	0.027	0.062	0.025	0.062	0.027	0.062
Resid_Size	-0.102**	0.045	-0.106**	0.045	-0.085*	0.043
Time-effects	Yes		Yes		Yes	
Wald $\chi2$	73.28***		77.65***		55.32***	
Log L	-374.94		-372.02		-375.3	
No. of observations	964		964		964	
No. of groups	103		103		103	

This table reports the results of the fixed-effects logistic (leverage/error direction) regressions (equations 3). The dependent variable is the dummy variable equal to 1 if *Weiss* reserve error is negative, and 0 otherwise. All remaining variables are defined as in the text. Bootstrapped standard errors are reported. ***, **, and * indicate significance at the 0.01, 0.05, and 0.10 levels (two-tailed), respectively.

TABLE 5

GMM-SYS Regression Test of Discretionary Reserving Behaviour in UK Property-Casualty Insurance Market 1991 to 2005: Leverage - Level of KFS Reserve Errors

	(1)		(2)		(3)	
Variable	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Intercept	0.148 *	0.085	0.146 *	0.089	0.051	0.038
lagKFS	0.809***	0.100	0.808***	0.101	0.821***	0.098
Leverage(1)	-0.655**	0.325	-0.683**	0.332		
Leverage(1)^2	0.655**	0.276	0.651**	0.283		
Leverage(2)					-0.023*	0.009
Leverage(2)^2					0.006*	0.003
Reinsurance	-0.038	0.026	-0.031	0.028	-0.038	0.026
Derivatives	-0.018*	0.010	-0.017*	0.009	-0.024*	0.013
Rein x Growth			-0.034*	0.019		
Growth	-0.003	0.005	-0.004	0.005	-0.008	0.007
ROA	-0.080*	0.043	-0.072*	0.040	-0.134*	0.082
Std_ROA	0.003*	0.002	0.003*	0.002	0.023*	0.013
Tax Shield	-0.001	0.003	-0.001	0.003	-0.001	0.003
Long-Tail	-0.002	0.044	-0.004	0.045	0.015	0.046
Product Mix	0.007	0.017	0.013	0.020	-0.009	0.016
Group	-0.015*	0.008	-0.017**	0.008	-0.015*	0.008
Public	-0.005	0.010	-0.005	0.011	-0.007	0.009
Age	0.002	0.003	0.003	0.003	-0.004	0.009
Resid_Size	0.015**	0.007	0.015**	0.007	0.018**	0.007
Time-effects	Yes		Yes		Yes	
Sargan-Hansen	0.522		0.496		0.684	
Diff-Sargan-Hansen	0.448		0.457		0.873	
AR(1)	0.001		0.000		0.001	
AR(2)	0.886		0.959		0.867	
No. of observations	1226		1226		1226	
No. of groups	151		151		151	
No. of instruments	118		118		118	

This table reports the results of the *KFS GMM-SYS* (leverage/error level) regressions (equation 6). The dependent variable is the level of *KFS* over/under reserve error scaled by total assets. All remaining variables are defined as in the text. Asymptotically robust standard errors are reported. Lagged levels (dated t-2,…,t-10) in the first-difference equations, combined with lagged first-differences (dated t-1) in the level equations, are used as instruments. The values reported for the Hansen *J*- test are the *p*-values for the null hypothesis of the validity of the instruments. The Difference Sargan-Hansen test gives the *p*-values for the validity of the additional moment restrictions required by the *GMM-SYS* estimator. Both of these tests do not reject the null hypotheses. AR(1) and AR(2) give the *p*-values for first-order and second-order auto-correlated disturbances in the first-difference equations. The null hypothesis is rejected for AR(1), but not AR(2), indicating that residuals are not correlated over time. ***, **, and * indicate significance at the 0.01, 0.05, and 0.10 levels (two-tailed), respectively.

TABLE 6

GMM-SYS Regression Test of Discretionary Reserving Behaviour in UK Property-Casualty Insurance Market 1991 to 2005: Leverage - Level of Weiss Reserve Errors

	(1)		(2)		(3)	
Variable	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef..**	**S.E..**
Intercept	0.135 *	0.084	0.131 *	0.089	0.067	0.035
lagWeiss	0.812***	0.078	0.811***	0.079	0.798***	0.078
Leverage(1)	-0.634**	0.320	-0.667**	0.331		
Leverage(1)^2	0.612**	0.275	0.653**	0.285		
Leverage(2)					-0.029*	0.017
Leverage(2)^2					0.006*	0.003
Reinsurance	-0.039	0.026	-0.030	0.029	-0.052*	0.027
Derivatives	-0.021*	0.012	-0.021*	0.012	-0.027**	0.013
Rein x Growth			-0.046*	0.027		
Growth	-0.005	0.006	-0.006	0.006	-0.007	0.007
ROA	-0.120**	0.058	-0.130**	0.052	-0.200*	0.098
Std_ROA	0.022*	0.011	0.026**	0.012	0.018**	0.008
Tax Shield	0.002	0.003	0.002	0.003	0.003	0.003
Long-Tail	0.005	0.038	0.003	0.038	0.023	0.041
Product Mix	0.008	0.017	0.016	0.020	0.012	0.014
Group	-0.012*	0.006	-0.014*	0.008	-0.012**	0.005
Public	-0.004	0.010	-0.004	0.011	-0.006	0.008
Age	0.002	0.003	0.003	0.003	-0.003	0.003
Resid_Size	0.014**	0.006	0.014**	0.007	0.017**	0.007
Time-effects	Yes		Yes		Yes	
Sargan-Hansen	0.496		0.472		0.6671	
Diff-Sargan Hansen	0.152		0.289		0.509	
AR(1)	0.000		0.000		0.000	
AR(2)	0.912		0.904		0.787	
No. of observations	1226		1226		1226	
No. of groups	151		151		151	
No. of instruments	118		118		118	

This table reports the results of the *Weiss GMM-SYS* (error/level) regressions (equation 6). The dependent variable is the level of *Weiss* over/under reserve error scaled by total assets. All remaining variables are defined as in the text. Asymptotically robust standard errors are reported. Lagged levels (dated t-2,…,t-10) in the first-difference equations, combined with lagged first-differences (dated t-1) in the level equations, are used as instruments. The values reported for the Sargan-Hansen *J*-test are the *p*-values for the null hypothesis of the validity of the instruments. The Difference Sargan-Hansen test gives the *p*-values for the validity of the additional moment restrictions required by the *GMM-SYS* estimator. Both of these tests do not reject the null hypotheses. AR(1) and AR(2) give the *p*-values for first-order and second-order auto-correlated disturbances in the first-difference equations. The null hypothesis is rejected for AR(1), but not AR(2), indicating that residuals are not correlated over time. ***, **, and * indicate significance at the 0.01, 0.05, and 0.10 levels (two-tailed), respectively.

TABLE 7

Regression Test of Discretionary Reserving Behaviour in UK Property-Casualty Insurance Market 1991 to 2005: Reserve Accuracy - Absolute Magnitude of KFS Reserve Errors

	(1)		**(2)**		**(3)**		**(4)**		**(5)**	
Variable	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Intercept	-0.055	0.062	-0.050	0.059	-0.064	0.077	0.031	0.054	0.017	0.047
lagKFS	0.817***	0.182	0.801***	0.186	0.802***	0.184	0.821***	0.1852	0.772***	0.171
Over-Reserving										
Leverage(1)	0.231*	0.192	0.255*	0.175	0.268*	0.233	0.158	0.169		
Leverage(1)^2	-0.126	0.159	-0.158	0.144	-0.162	0.184	-0.081	0.141		
Leverage(2)									0.013	0.018
Leverage(2)^2									-0.041	0.047
Reinsurance	-0.052**	0.023	-0.071***	0.026	-0.051**	0.020	-0.040*	0.025	-0.041*	0.027
Proportional							0.176	0.135		
Derivatives	-0.001	0.011	-0.005	0.011	-0.007	0.011	-0.006	0.009	-0.008	0.016
Rein x Growth			-0.017	0.028						
Rein x Deriv					-0.004	0.008				
Growth	-0.008	0.007	-0.008	0.008	-0.008	0.007	-0.007	0.007	-0.011	0.010
ROA	-0.079*	0.040	-0.066*	0.041	-0.064*	0.040	-0.051*	0.029	-0.059*	0.038
Std_ROA	0.014*	0.008	0.016*	0.010	0.014*	0.008	0.014*	0.008	0.015*	0.009
Tax Shield	-0.007	0.005	-0.007	0.005	-0.007	0.005	-0.006	0.005	-0.009	0.007
Long-Tail	-0.050*	0.030	-0.058*	0.035	-0.050*	0.030	-0.048*	0.029	-0.037*	0.022
Product Mix	-0.027*	0.015	-0.027*	0.015	-0.028*	0.016	-0.024*	0.015	-0.025*	0.015
Group	-0.021**	0.010	-0.019*	0.011	-0.021**	0.011	-0.013*	0.007	-0.013*	0.007
Public	-0.012*	0.006	-0.010*	0.005	-0.013*	0.007	-0.011*	0.006	-0.004	0.007
Age	-0.006*	0.004	-0.006*	0.004	-0.006*	0.003	-0.007*	0.004	-0.003	0.003
Resid_Size	0.002	0.006	0.002	0.007	0.003	0.006	0.002	0.006	0.002	0.007
Under-Reserving										
Leverage(1)	0.740*	0.401	0.777**	0.398	0.826*	0.458	0.723*	0.383		
Leverage(1)^2	-0.849**	0.396	-0.857**	0.393	-0.890**	0.442	-0.828**	0.377		
Leverage(2)									0.026*	0.012
Leverage(2)^2									-0.011*	0.005
Reinsurance	-0.099**	0.045	-0.077 *	0.046	-0.074	0.051	-0.100*	0.043	0.051	0.057
Proportional							0.118	0.166		
Derivatives	0.005	0.032	0.001	0.033	0.007	0.028	0.006	0.034	-0.015	0.029
Rein x Growth			0.167**	0.076						
Rein x Deriv					-0.006	0.016				
Growth	-0.008	0.023	-0.015	0.026	-0.010	0.023	-0.012	0.023	0.015	0.021
ROA	0.097*	0.058	0.080*	0.051	0.094*	0.057	0.086*	0.051	0.129*	0.069
Std_ROA	-0.001	0.002	-0.001	0.002	-0.001	0.003	-0.002	0.003	-0.002	0.003
Tax Shield	-0.024	0.024	-0.025	0.023	-0.025	0.025	-0.022	0.023	-0.005	0.015
Long-Tail	-0.016	0.047	-0.028	0.047	-0.021	0.051	-0.028	0.047	-0.094*	0.050
Product Mix	-0.042	0.033	-0.047	0.035	-0.048	0.032	-0.047	0.033	-0.035	0.024
Group	0.113**	0.051	0.101**	0.045	0.103**	0.047	0.104**	0.047	0.043*	0.024
Public	-0.001	0.025	0.004	0.024	-0.004	0.025	-0.003	0.023	-0.011	0.016
Age	-0.013*	0.007	-0.017***	0.006	-0.015**	0.008	-0.015**	0.007	-0.014**	0.006
Resid_Size	0.008	0.008	0.008	0.008	0.009	0.007	0.008	0.007	0.002	0.007
Time Effects	Yes		Yes		Yes		Yes		Yes	
Sargan-Hansen	0.317		0.657		0.207		0.497		0.484	
Diff Sargan-Hansen	0.188		0.268		0.570		0.668		0.388	
AR(1)	0.004		0.004		0.004		0.003		0.004	
AR(2)	0.762		0.743		0.811		0.761		0.678	
No. of observations	1226		1226		1226		1226		1226	
No. of groups	151		151		151		151		151	
No. of instruments	136		148		148		148		136	

This table reports the results of the *KFS GMM-SYS* (reserve accuracy) regressions (equation 8). The dependent variable is the absolute value of *KFS* reserve error scaled by total assets. All remaining variables are as in the text. Asymptotically robust standard errors are reported. Lagged levels (dated t-2,…, t-6) in the first-difference equations, combined with lagged first-differences (dated t-1) in the level equations, are used as instruments. The values reported for the Sargan-Hansen *J*-test are the *p*-values for the null hypothesis of the validity of the instruments. The Difference Sargan-Hansen test gives the *p*-values for the validity of the additional moment restrictions required by the *GMM-SYS* estimator Both of these tests do not reject the null hypotheses. AR(1) and AR(2) give the *p*-values for first-order and second-order auto-correlated disturbances in the first-difference equations. The null hypothesis is rejected for AR(1), but not AR(2), indicating that residuals are not correlated over time. ***, **, and * indicate significance at the 0.01, 0.05, and 0.10 levels (two-tailed), respectively.

TABLE 8

Regression Test of Discretionary Reserving Behaviour in UK Property-Casualty Insurance Market 1991 to 2005: Reserve Accuracy - Absolute Magnitude of Weiss Reserve Errors

	(1)		(2)		(3)		(4)		(5)	
Variable	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Intercept	-0.053	0.074	-0.054	0.064	-0.052	0.077	-0.041	0.069	0.034	0.037
lagWeiss	0.711***	0.153	0.693***	0.154	0.681***	0.153	0.702***	0.153	0.647***	0.149
Over-Reserving										
Leverage(1)	0.363*	0.258	0.378*	0.219	0.296*	0.265	0.333*	0.233		
Leverage(1)^2	-0.225	0.219	-0.246	0.181	-0.173	0.225	-0.205	0.197		
Leverage(2)									-0.004	0.015
Leverage(2)^2									0.005	0.004
Reinsurance	-0.053**	0.026	-0.053**	0.024	-0.057**	0.025	-0.056**	0.026	-0.032*	0.014
Proportional							-0.005	0.119		
Derivatives	-0.009	0.013	-0.008	0.011	-0.015	0.012	-0.008	0.011	-0.003	0.015
Rein x Growth			0.007	0.021						
Rein x Deriv					0.003	0.007				
Growth	-0.021**	0.011	-0.017*	0.009	-0.020**	0.010	-0.021**	0.010	-0.022**	0.011
ROA	-0.122*	0.072	-0.116*	0.065	-0.099*	0.060	-0.122*	0.068	-0.080*	0.048
Std_ROA	0.030**	0.013	0.025**	0.012	0.028**	0.012	0.030**	0.013	0.028**	0.011
Tax Shield	-0.002	0.004	-0.002	0.004	-0.001	0.004	-0.002	0.004	-0.004	0.004
Long-Tail	-0.054*	0.030	-0.050*	0.030	-0.060*	0.032	-0.060*	0.033	-0.048*	0.030
Product Mix	-0.024*	0.014	-0.026*	0.015	-0.031**	0.015	-0.025*	0.014	-0.021*	0.010
Group	-0.014*	0.008	-0.012*	0.007	-0.013*	0.007	-0.014*	0.007	-0.006	0.009
Public	-0.014*	0.008	-0.012*	0.007	-0.014*	0.007	-0.015**	0.008	-0.005	0.007
Age	-0.003	0.003	-0.002	0.003	-0.002	0.003	-0.002	0.003	-0.001	0.003
Resid_Size	0.001	0.006	0.001	0.006	0.003	0.006	0.002	0.005	0.001	0.006
Under-Reserving										
Leverage(1)	0.775**	0.439	0.790**	0.403	0.780**	0.450	0.724**	0.411		
Leverage(1)^2	-0.941 **	0.444	-0.900 **	0.419	-0.898 **	0.443	-0.883**	0.413		
Leverage(2)									0.046*	0.022
Leverage(2)^2									-0.015*	0.008
Reinsurance	-0.118 **	0.055	-0.063	0.058	-0.062	0.052	-0.108 **	0.052	-0.047	0.047
Proportional							0.048	0.134		
Derivatives	0.030	0.040	0.023	0.036	0.017	0.032	0.014	0.037	0.005	0.028
Rein x Growth			0.192**	0.096						
Rein x Deriv					-0.013	0.017				
Growth	-0.007	0.026	-0.020	0.028	-0.015	0.024	-0.006	0.025	0.021	0.027
ROA	0.092*	0.061	0.075*	0.045	0.080 *	0.047	0.088*	0.048	0.140*	0.079
Std_ROA	-0.003	0.003	-0.002	0.003	-0.002	0.003	-0.002	0.003	-0.002	0.003
Tax Shield	-0.093*	0.050	-0.102**	0.047	-0.091*	0.050	-0.087*	0.050	-0.054	0.038
Long-Tail	0.042	0.066	0.037	0.058	0.023	0.066	0.032	0.065	-0.068	0.066
Product Mix	-0.028	0.038	-0.033	0.039	-0.040	0.036	-0.027	0.036	-0.033	0.027
Group	0.077**	0.038	0.071**	0.035	0.062*	0.034	0.073**	0.035	0.033*	0.019
Public	0.007	0.039	0.010	0.037	0.001	0.037	0.005	0.037	-0.013	0.017
Age	-0.020***	0.008	-0.018***	0.007	-0.020***	0.008	-0.021***	0.007	0.016**	0.006
Resid_Size	0.013 *	0.007	0.010	0.008	0.013 *	0.007	0.011 *	0.007	0.004	0.007
Time Effects	Yes		Yes		Yes		Yes		Yes	
Hansen	0.275		0.225		0.289		0.234		0.315	
Diff-Hansen	0.448		0.301		0.340		0.216		0.394	
AR(1)	0.001		0.001		0.001		0.001		0.002	
AR(2)	0.923		0.875		0.931		0.949		0.350	
No. of observations	1226		1226		1226		1226		1226	
No. of groups	151		151		151		151		151	
No. of instruments	136		148		148		148		136	

This table reports the results of the *Weiss GMM-SYS* (reserve accuracy) regressions (equation 8). The dependent variable is the absolute value of *Weiss* reserve error scaled by total assets. All remaining variables are defined as in the text. Asymptotically robust standard errors are reported. Lagged levels (dated t-2, …, t-6) in the first-difference equations, combined with lagged first-differences (dated t-1) in the level equations, are used as instruments. The values reported for the Hansen *J*-test are the *p*-values for the null hypothesis of the validity of the instruments. The Difference-Hansen test gives the *p*-values for the validity of the additional moment restrictions required by the *GMM-SYS* estimator. Both of these tests do not reject the null hypotheses. AR(1) and AR(2) give the *p*-values for first-order and second-order auto-correlated disturbances in the first-difference equations. The null hypothesis is rejected for AR(1), but not AR(2), indicating that residuals are not correlated over time. ***, **, and * indicate significance at the 0.01, 0.05, and 0.10 levels (two-tailed), respectively.