

Underwriting Discipline

By

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Abstract

The costs of financial products often remain uncertain until many years after they are sold. To set prices that will cover their costs, financial institutions, such as banks and insurers, evaluate prospective customers' risk profiles – a process known as underwriting. For insurers, the return on underwriting, i.e. the return from selling insurance policies, reflects the cost of financing the firm with risky debt capital supplied by policyholders: profitable underwriting means that an insurer borrows at a negative interest rate. Among non-life insurers, the return on underwriting of the top quintile of firms exceeds the bottom quintile by over 40 percentage points in most years. We distinguish between luck and strategy in insurers' underwriting performance and document an empirical puzzle: there are considerable differences amongst insurers with respect to underwriting discipline, even when they have a similar business mix and financial quality. Less disciplined insurers, whose insurance operations are consistently unprofitable, rely on investments as a source of income: they have riskier investment portfolios but are unable to achieve superior investment performance on a risk-adjusted basis.

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Chapter 1

Introduction

An insurance company's operation can be structurally represented as a leveraged investment fund: by issuing policies, insurers gain access to policyholder-supplied debt capital (premiums), which they invest to pay future policyholder claims. Compared to investment funds, the less favorable tax and regulatory environment puts insurers at a disadvantage in their ability to create value through investment.¹ Insurers' comparative advantage lies with their ability to finance themselves by raising risky debt through the insurance market. If an insurer sells policies for \$100 million in premiums and pays \$95 million in losses and related expenses, it essentially borrowed \$100 million at the interest rate of negative 5%. In insurance terminology, this is referred to as earning a 5% return on underwriting.

The actual cost of policyholder-supplied debt varies considerably across insurers. From 1991 to 2009, the average return on underwriting obtained by the lowest quintile of U.S. non-life insurers is -19%, while it is 23% for the highest quintile. Part of this variation is due to the random nature of insurance losses: at the time of selling policies, insurers must evaluate prospective customers' risk – a process known as underwriting – to ensure that the premiums will be sufficient to cover

¹ See, e.g., Froot (1999), Zanjani (2002), Harrington (2009).

future losses. It is often argued, however, that some insurers lack *underwriting discipline*, i.e. that there are systematic misalignments between the prices and costs of their products, whether due to a lack of underwriting skill or strategic considerations.

In this study, we address two questions. First, are there systematic differences in insurers' underwriting discipline? To the extent that some insurers have stronger (weaker) underwriting discipline, indicating an ability to raise policyholder-supplied debt at a lower (higher) cost, the comparative advantage hypothesis suggests these firms will take less (more) investment risk. Our second question therefore is: what is the relationship between insurers' underwriting discipline and investment strategy?

To answer these questions, we first develop a methodology for studying underwriting discipline – a quality that is not directly observable. We define underwriting discipline as an insurer's ability to: (i) accurately forecast the timing and amount of future loss payments; (ii) set a premium that covers the economic cost of writing the business; and (iii) decline coverage if this premium cannot be obtained. The flexibility of this definition allows us to study the differences in insurers' underwriting discipline both in absolute terms, e.g. whether an insurer operates at an underwriting profit or loss, and in relative terms, e.g. where an insurer stands relative to competitors. Our approach is based on the following assumption: firms with stronger underwriting discipline will not only achieve strong underwriting results but also do so consistently. We study the consistency of insurer underwriting performance along two dimensions: over time and across product lines.

We begin to explore whether insurers differ with respect to underwriting discipline by testing if some insurers consistently attain underwriting profits while others operate at an underwriting

loss. We find strong evidence that this is indeed the case, even when we account for the differences in the duration of insurer liabilities. Specifically, we count how many insurers have underwriting profits (or losses) over rolling three-year periods and then compare these results with those generated from a simulation model that assumes no serial correlation in an insurer's underwriting profitability beyond the serial correlation induced by overall trends in the industry's underwriting profitability. The simulation shows that there is significantly more consistency in observed underwriting performance than random luck could explain: there is less than 1 in 10,000 chance that the observed amount of consistency could arise if there were no differences in underwriting discipline.

The differences in insurer underwriting performance persist over many years. For example, the insurers that had three consecutive years of underwriting losses from 2001 to 2003 have significantly worse underwriting results in every other sample period year (1991-2000; 2004-2009) than the insurers that had three consecutive years of underwriting gains from 2001 to 2003. The difference in underwriting results is large. For example, in 1991, ten years prior to the 2001 to 2003 window, underwriting profits per one million dollars in net premiums earned (the average insurer in 1991 has 187 million dollars in net premiums earned) are on average \$96,555 for insurers that had three consecutive years of underwriting gains in the 2001 to 2003 period, and \$9,131 for insurers that had three consecutive years of underwriting losses. The difference is not driven by outliers: the difference between the two groups' median results is of similar size and also statistically significant throughout the entire sample period.

We next examine whether the observed differences and consistency in underwriting performance can be explained by differences in insurer business mix. Our tests strongly reject this

possibility; in fact, the consistent differences in underwriting performance become even more pronounced after we account for insurer business mix. We find that for most insurers, the key to consistent underwriting profits is outperforming peers with a similar business mix, rather than cherry-picking lines of business. Moreover, a simulation analysis *within* each line of business reveals that there are consistent differences in underwriting profitability among insurers in almost every line (medical professional liability in late 1990s – early 2000s is one exception). An additional robustness check rules out differences in insurer financial quality (A.M. Best ratings) as an alternative explanation of consistent differences in underwriting profitability.

In addition to the consistency of underwriting performance over time, we study how consistent an insurer's underwriting performance is across the lines of business it writes. We find that the majority of multiline insurers with consistently superior (subpar) overall underwriting performance also have better (worse) than average results in most lines they write. This indicates that both superior and subpar underwriting performance is not driven by excelling or underperforming in a limited number of lines, but rather it is due to firm-level differences in underwriting discipline.

After documenting meaningful differences in underwriting discipline, we explore how insurers' underwriting discipline relates to their investment strategy. We find that less disciplined insurers allocate a greater portion of their investment portfolio to risky assets. Insurers that we identify as having weak (medium) underwriting discipline allocate 7.47% (5.88%) more assets to risky investments relative to insurers with strong underwriting discipline, all else equal. This variation in investment risk taking is remarkable given that insurers face strict regulatory restrictions on the types of assets they can invest and the amount they can invest in each asset type.

There is little evidence, however, that insurers with weaker underwriting discipline are able to attain superior investment performance on a risk-adjusted basis. These results indicate that many insurers sacrifice the profitability of their core business even though they do not have a comparative advantage in investing.

Our study has implications for the insurance industry, regulators and policymakers, and for the economy at large. Our finding that insurers with weaker underwriting discipline take more investment risk represents a regulatory and policy concern. The amount of underwriting discipline in the insurance industry is important for the economy, because it affects the availability and affordability of insurance coverage. Excessively strict underwriting standards can result in high insurance prices or coverage being difficult to obtain. On the other hand, insufficient underwriting discipline can endanger insurer solvency. Insurance regulators must consider this tradeoff. Insurance companies, in turn, face a tradeoff as well: too little underwriting discipline, especially when coupled with a riskier investment portfolio, may lead to solvency issues, too much underwriting discipline may limit opportunities for growth.

Underwriting discipline is an issue that is relevant outside the insurance industry. Concerns about insufficient underwriting discipline regularly appear in various lending markets;² however, the academic literature in this area is limited. Existing studies mostly focus on the role of underwriting discipline in the subprime mortgage crisis. Keys et al. (2008) and Mayer et al. (2009) document intentional loosening of underwriting standards in the subprime mortgage market as a major factor contributing to the financial crisis, while Demyanyk and van Hemert (2009) argue

² One example is the statement released by the Federal Reserve in December 2015: “The agencies have observed ... an easing of CRE [commercial real estate] underwriting standards. Financial institutions should maintain underwriting discipline...”

that the deterioration could have been detected as much as six years prior to the crisis. Fahlenbrach et al. (2018) explore why fast loan growth predicts poor performance and argue that banks in the top quartile of credit growth are overoptimistic about the risk of loans. This dissertation extends this literature in a number of ways. We are the first we know to explicitly define the notion of underwriting discipline and propose ways to measure this quality empirically. Further, we provide evidence that weak underwriting performance does not necessarily result from biased beliefs and can be driven by the strategic decisions of a financial institution.

The remainder of this dissertation has the following structure. In Chapter 2, we discuss the industry trends and describe our data. Chapter 3 examines whether there are meaningful differences in insurer underwriting discipline. In Chapter 4, we analyze the relationship between underwriting discipline and investment strategy. Chapter 5 concludes.

Chapter 2

Institutional Setting and Data.

In this section, we explain how underwriting profitability is measured in the insurance industry, introduce two important modifications of the standard measure, and discuss the variation in underwriting profitability over time and across firms.

2.1 Dataset and sample selection procedures.

The data source for our analyses is the 1991 to 2014 National Association of Insurance Commissioners (NAIC) Property-Casualty Annual Statement Database. The database provides insurance company financial information and detailed information about insurers' underwriting and investment activities. An advantage of this dataset is that it is not limited to publicly traded firms: our sample includes both publicly traded and privately owned stock insurers as well as mutual insurers.³ Many insurance firms are organized as a group of firms under common ownership,⁴ while other insurers are unaffiliated with a group. For the analyses described in the

³ All results are also robust to the inclusion of insurers with a less common organizational form (reciprocal and Lloyd's insurers and risk retention groups).

⁴ State Farm, for example, has seventeen separately capitalized companies within its group. Our analyses described in the next sections yield similar results when replicated at the group and unaffiliated single level.

next sections, our sample consists of affiliated and unaffiliated individual insurers. The analyses yield similar results when replicated at the group and unaffiliated single level.

To be included in our sample, an insurer must have total net premiums earned and written, direct premiums written, total assets, and policyholder surplus of at least one million dollars, as well as positive losses and underwriting expenses (all net of reinsurance), and an AM Best's financial strength rating above D ("Poor"). Additionally, we exclude firms with more than 25% of net premiums earned in reinsurance or more than 50% of net premiums earned in nontraditional property-liability lines of insurance (credit, fidelity, surety, financial guaranty, mortgage guaranty, warranty, or accident and health) (Deng, Leverty and Zanjani, 2017). Our resulting sample includes 973 to 1,142 insurers per year, with 1,836 unique insurers. To ensure that our results are not driven by insurers that exit and enter the industry, we perform a robustness check in which we rerun all the analyses described below for the subsample of insurers that remain present throughout our 24 year sample period, 1991-2014 (see Appendix A for details). All results are qualitatively and quantitatively similar for this subsample.

2.2 Measures of underwriting profitability and industry trends.

2.2.1 Return on underwriting.

A measure of underwriting profitability is the return on underwriting, which compares the premiums collected from insurance policies with the losses and expenses arising from selling and servicing these policies.⁵ The return on underwriting for insurer i in year t is:

⁵ In the industry, underwriting performance is often evaluated using the complement of the underwriting returns – the combined ratio, defined as 100% minus the underwriting return. Another ratio that is often used to evaluate

$$R_{it} = \frac{Premiums_{it} - Losses_{it} - UW_Expenses_{it}}{Premiums_{it}} \cdot 100\%, \quad (1)$$

where $Premiums_{it}$ are total premiums earned; $Losses_{it}$ are total losses incurred, including loss adjustment expenses; and $UW_Expenses_{it}$ are underwriting expenses other than loss adjustment expenses (all variables are net of reinsurance).⁶

Higher values of underwriting returns correspond to better underwriting performance. A positive (negative) underwriting return indicates an underwriting profit (loss). The mean underwriting return during our sample period (1991 to 2009) is –6% and the standard deviation is 17 percentage points. There is considerable variation in insurer results each year: the difference between the 95th and 5th (75th and 25th) percentiles ranges from 38 to 53 (11 to 17) percentage points, depending on the year. The median insurer recorded underwriting losses from 1991 to 2002, underwriting profits from 2003 to 2007, and returned to underwriting losses in 2008-2009.

2.2.2 Realized return on underwriting.

$Losses_{it}$ in Eq. (1) are reported by an insurer at the end of year t and represent the insurer's initial estimate of the total losses incurred on the policies that were in force during year t . As losses are

underwriting performance is the loss ratio – the ratio of losses incurred to premiums earned. Our results are robust to using either the realized combined ratio or the realized loss ratio.

⁶ Premiums earned and losses incurred are obtained from Schedule P. Underwriting expenses by line of business are obtained from the Insurance Expense Exhibit. To reduce the impact of outliers, we winsorize the realized underwriting return at 1% (on both sides, by year). We believe winsorizing is more appropriate for our analyses than excluding outliers because it retains the information that an insurer had a very strong or very poor underwriting performance without dominating our numerical estimates; however, all results are robust to excluding outliers.

paid out over time, insurers are required to disclose revisions to their initial loss estimates. The initial estimates often contain considerable uncertainty: although the coverage period of most property-liability insurance policies is relatively short-term, up to one year, the payment of losses – and hence determination of their full amount – can spread over many years. The various lines of business offered by insurers have different payout characteristics: Nelson (2000) reports the average time to claims development exhaustion (i.e., when *all* outstanding claims are paid) is 7 years for homeowners insurance and 20 years for medical malpractice insurance. Moreover, a large body of literature finds that insurers manage loss reserve estimates for various reasons including tax optimization (e.g., Grace, 1990), financial weakness (e.g., Petroni, 1992; Harrington and Danzon, 1994; Gaver and Paterson, 2004; Grace and Leverty, 2012), income smoothing (Weiss, 1985; Beaver, McNichols, and Nelson, 2003), rate regulation (Nelson, 2000; Grace and Leverty, 2010), and executive compensation (Eckles and Halek, 2010; Eckles et al, 2011).

We make two important adjustments to the underwriting returns to enhance the accuracy of our analyses. First, to capture insurers' actual underwriting performance rather than their initial projections, we replace the initial estimate of losses incurred in year t (as reported at the end of year t) with developed losses – an updated estimate of losses incurred after five years of development (losses incurred in year t , as reported at the end of year $t + 5$). Second, we calculate the present value of losses. Premiums are paid in advance of loss payments, and the expected timing of loss payments is priced into them; therefore, using the present value of losses aligns losses with premiums and accounts for the differences in payout patterns of various lines of business (Winter 1994, Cummins and Danzon 1997). The present value of losses is calculated by applying Taylor separation methods to the data from Schedule P of the regulatory annual statement

that provides information on the reserve runoffs of different lines of insurance,⁷ and discounting is performed using U.S. Treasury yield curves.⁸

We call the adjusted measure of underwriting performance the realized underwriting return.

The realized underwriting return of insurer i in year t is calculated as follows:

$$UWRET_{it} = \frac{Premiums_{it} - PV(DevLosses_{it}) - UW_Expenses_{it}}{Premiums_{it}} \cdot 100\%, \quad (2)$$

where $Premiums_{it}$ are total premiums earned; $PV(DevLosses_{it})$ is the present value of developed losses incurred, including loss adjustment expenses; and $UW_Expenses_{it}$ are underwriting expenses by insurer i in year t (all variables are net of reinsurance). Similar to the traditional underwriting return, better underwriting results correspond to higher values of the realized underwriting return.

The annual distributions of the realized underwriting returns for 1991 to 2009 are shown in Figure

1.⁹ Our adjustments to the underwriting return have two effects. First, the realized underwriting

⁷ Lines of business reported in Schedule P include homeowners/farmowners, private auto liability, commercial auto liability, workers' compensation, commercial multiple peril, medical professional liability, special liability (which includes ocean marine, aircraft, and boiler & machinery), other liability, special property (which includes fire, allied lines, inland marine, earthquake, and burglary & theft), fidelity/surety, financial guaranty/mortgage guaranty, warranty, other coverage (incl. credit and accident & health), as well as nonproportional reinsurance and international coverage.

⁸ The standard Taylor separation method assumes that the timing of loss payments varies by line of business and year but not by insurer, i.e. two insurers with the same business mix in the same year will have the same timing of loss payments. However, some insurers could focus on the longer-tail coverage within the same line of business. If such differentiation is present but not properly accounted for, we would incorrectly classify these insurers as having below-average underwriting discipline. Therefore, we calculate the present value of losses using an alternative approach, which utilizes each insurer's actual timing of loss payments (obtained from Schedule P). Again, the results remain mostly unaffected.

⁹ Because we use the revised estimates of losses and loss expenses after five years of development, the last year for which we are able to calculate the realized underwriting return is 2009.

return is higher for the median firm than the initial underwriting return: the median insurer's realized underwriting return is positive in all years except the four-year period from 1998 to 2001. The mean realized underwriting return during our sample period is 2%. This indicates that the initial underwriting return underestimates the underwriting performance of the mean and median insurer. Second, there is considerably more variation in the realized underwriting return: the sample standard deviation is 19 percentage points and the difference between the 95th and 5th (75th and 25th) percentiles ranges from 47 to 63 (13 to 18) percentage points.

[Figure 1]

Chapter 3

Consistency of Underwriting Performance.

3.1 Consistency over time.

In this section, we study the consistency of U.S. P/L insurers' underwriting profitability over time. First, we test whether the amount of consistency present in the industry could plausibly arise if insurers did not differ with respect to underwriting discipline. After documenting significantly more consistency than random luck could explain, we study how stable the observed differences in insurer underwriting profitability remain over time.

Underwriting discipline means that an insurer sets rates commensurate with expected losses. As the amount of future losses is not known with certainty at the time a policy is sold, an insurer's realized underwriting return in any one period is either above or below its target. Differences in underwriting discipline, if they exist, would mean that insurers *target* different values of the underwriting return. If we observe two insurers for only one period, we cannot tell whether the difference in their underwriting results stems from the difference in their targets or simply from random luck. However, if we observe these insurers' results over several periods, we might find that one *tends* to have better underwriting returns than the other.

3.1.1 A simple measure of consistency of underwriting performance over time.

There are many ways to quantify the notion of persistent differences in insurer underwriting performance over time. Before we develop more sophisticated measures later in this chapter, a natural starting point is to test whether some insurers consistently operate at an underwriting profit ($UWRET_{it} \geq 0\%$) while others repeatedly record underwriting losses. Thus, we define the following measure of consistency in insurer underwriting results over k years:

$$UWRET_CONSISTENCY_{it} = \begin{cases} CONSISTENT_PROFIT & \text{if } UWRET_{it} \geq 0\% \text{ in each year between } t - k + 1 \text{ and } t \\ CONSISTENT_LOSS & \text{if } UWRET_{it} < 0\% \text{ in each year between } t - k + 1 \text{ and } t \\ INCONSISTENT & \text{otherwise} \end{cases} \quad (3)$$

where *CONSISTENT_PROFIT* (*CONSISTENT_LOSS*) means that insurer i has underwriting profits (losses) in each of the k years and *INCONSISTENT* is the label for inconsistent performance.¹⁰

Figure 2, Panel A shows the percentage of insurers in each of the three groups. We report the results with the number of years, k , set equal to 3; however, all results reported below still hold, with similar levels of statistical significance, when $UWRET_CONSISTENCY_{it}$ is defined based on 4- or 5-year periods. For most three-year periods, the majority of insurers have either consistent

¹⁰ In addition to setting the threshold underwriting return equal to zero (i.e. underwriting profit versus loss), we explore setting the threshold equal to the annual average or median underwriting return (i.e. whether an insurer's underwriting performance is better or worse than the industry average or median in a given year). These alternative approaches yield similar results.

underwriting profits or losses. Over the entire sample period, *CONSISTENT_PROFIT* and *CONSISTENT_LOSS* insurers represent respectively 41.63% and 16.82% of observations, and *INCONSISTENT* insurers account for 41.54% of the sample.

[Figure 2]

3.1.2 Simulation analysis: comparison of observed consistency with simulated outcomes.

To determine whether the observed degree of consistency could plausibly arise due to random luck alone, we perform a simulation analysis. The goal of the simulation is to estimate what proportion of insurers we would observe in each of the three groups under the hypothesis that insurers do not differ with respect to underwriting discipline. Intuitively, the null hypothesis of the simulation assumes that there is no serial correlation in an insurer's underwriting profitability beyond the serial correlation induced by overall trends in the industry's underwriting profitability. In contrast, if insurers differ with respect to underwriting discipline, then there will be serial correlation in their underwriting profitability beyond the serial correlation induced by industry trends. Unlike pairwise correlations, the simulation allows us to examine the consistency of an insurer's underwriting profitability over several years. The more involved analyses in the following subsections, where we refine the measurement of consistency to account for differences in insurer business mix and firm characteristics, also use a simulation framework.

Note that if the null hypothesis of no differences in underwriting discipline is true, then each year's proportion of insurers with underwriting losses, q_{loss} , can be viewed as an estimate of the

hypothetical common probability of an underwriting loss that year. For each insurer in each year we simulate whether it had an underwriting loss by drawing from a Bernoulli distribution with the probability of success equal to that year's q_{loss} . Next, we use the simulated results to calculate the yearly proportions of *CONSISTENT_PROFIT*, *CONSISTENT_LOSS* and *INCONSISTENT* insurers. We repeat this procedure 10,000 times, each time recording the three proportions for each year.¹¹

Figure 2, Panel A presents the observed underwriting results. Panel B presents the simulation results -- the means of 10,000 realizations of the yearly proportions of insurers in each of the three groups. The figure shows that there is more consistency in observed underwriting performance than what would be expected from a random assignment of underwriting performance.

Table 1 shows that the observed and simulated breakdowns of underwriting performance are statistically different. The actual proportion of insurers in either consistent group (profit or loss) is larger than the maximum of the 10,000 simulated proportions in all sample years. For example, in 2009, 47% of insurers were in the *CONSISTENT_PROFIT* group, 10% were in the *CONSISTENT_LOSS* group, and 43% were *INCONSISTENT*. If all insurers were equally likely to have an underwriting loss, we would expect 22-34% of insurers to be in the *CONSISTENT_PROFIT* group, 1-5% in the *CONSISTENT_LOSS* group and 63-75% in the *INCONSISTENT* group. Thus, we would expect significantly fewer insurers in the two consistent groups and significantly more insurers in the inconsistent group if the hypothesis of no differences

¹¹ Note that the procedure requires that firms be in the sample for at least three consecutive years. To the extent that new entrants and insurers exiting the market are more likely to have anomalous underwriting performance, their exclusion from the sample likely biases the results away from finding significant differences in underwriting discipline, as it makes the sample more homogeneous. Nevertheless, we rerun all the analyses in this paper for the subsample of insurers that are present throughout our sample period; all of our findings still hold for this subsample (see Appendix A for details).

in underwriting strategy was true. Therefore, we reject this hypothesis at the 0.0001 significance level and conclude that insurers differ with respect to their underwriting discipline.

[Table 1]

3.1.3 Consistency of underwriting performance over time.

After obtaining this initial evidence that insurers differ with respect to underwriting discipline, we next investigate how stable these differences remain over time. We classify insurers as *CONSISTENT_PROFIT*, *CONSISTENT_LOSS* or *INCONSISTENT* based on their underwriting results over a three-year period and then compare the underwriting performance of the three groups in the years preceding and following the three-year period used for classification.

Any three-year period can be chosen for classification; we try all 17 possible three-year periods and find that the results described below are robust to the choice of the classification period. Here, we report the results for two classification periods: the last three years of our sample (2007 through 2009) and 2001 through 2003. Classification based on the last three years is convenient because it allows us to compare the groups' underwriting performance up to 16 years prior to the classification period, while at the same time mitigating the survivorship bias that could affect a similar analysis based on the first three years of the sample period. The 2001 to 2003 period is chosen because many insurance companies had underwriting losses during this period (see Figure 1): observing an insurer's underwriting performance is likely more informative during a challenging period than during a period when most insurers are able to obtain good results.

We compare the *CONSISTENT_PROFIT* and *CONSISTENT_LOSS* groups' underwriting performance in all years before and after the classification period. The results are presented in Figure 3, with the statistical tests documented in Table 2. First, we compare the means of the realized underwriting return in the two groups. The average realized underwriting return of the insurers classified as *CONSISTENT_PROFIT* based on the 2007-2009 period is higher than that of the *CONSISTENT_LOSS* group in 14 out of the 16 years preceding the classification period; the difference is statistically significant for 9 of those years (according to a *t*-test). Already in 1991, 16 years prior to the classification period, the difference between the two groups' average returns is 7 percentage points and is statistically significant at the 0.01 level. However, as few insurers had underwriting losses in 2007 to 2009, the sample size of the *CONSISTENT_LOSS* group is quite small, especially in the earlier years. When the more challenging period of 2001 to 2003 is used for classification, the two groups' mean realized underwriting returns remain significantly different throughout the entire sample period, i.e. the difference between the groups is apparent as early as ten years prior to the classification period and remains present until the end of our sample period, i.e. for an additional eight years. Depending on the year, the difference between the two groups' mean realized underwriting returns ranges from 4 to 17 percentage points.

[Figure 3]

[Table 2]

Second, we test whether the observed difference in the groups' means is driven by outliers. Using the medians instead of the means of the two groups' realized underwriting returns yields similar results: the difference remains significantly positive (according to a Wilcoxon rank sum test) in 8 out of 16 years for the 2007-2009 classification period and in all 16 years when the 2001-2003 period is used for classification. The range of the difference between the two groups' medians is similar to the range for the means. We additionally compare what percentage of insurers in each group record underwriting profits in the years before and after the classification period. A significantly greater percentage of insurers in the *CONSISTENT_PROFIT* group records underwriting profits than in the *CONSISTENT_LOSS* group in 9 years outside of the 2007-2009 classification period and in all 16 years outside of the 2001-2003 classification period.

Overall, the results suggest that differences in insurer underwriting performance are quite stable over time, which is indicative of different levels of underwriting discipline.

3.2 Consistency over time – accounting for insurer business mix.

The analyses in the previous subsection indicate that the differences in insurers' underwriting performance remain consistent over time. One potential source of the consistency could lie with the insurer choosing wisely in which lines of business to operate: the average underwriting return can vary by line of business due to factors such as competition among insurers, perceived risk or complexity of writing a line, etc. Accordingly, in this subsection, we examine whether the observed differences in insurer underwriting performance remain consistent over time after we account for lines of business.

3.2.1 Abnormal realized underwriting return.

To account for insurer business mix we use *the abnormal realized underwriting return (AUWRET)*. The *AUWRET* of insurer i in year t as the difference between the insurer's realized underwriting return and its expected realized underwriting return given its exposure to external factors such as industry-wide shocks:

$$AUWRET_{it} = UWRET_{it} - E[UWRET_{it} | X_{it}], \quad (4)$$

where X_{it} are firm-specific and industry-wide variables. The firm-specific variables that we use include the percentage of net premiums earned, fr_{itl} , by insurer i in year t in line of business l . Industry-wide variables include year fixed effects, α_t , which represent industry- or economy-wide conditions that can affect insurer underwriting performance.¹² The expected realized underwriting return for insurer i in year t is therefore estimated as:

$$E[UWRET_{it} | X_{it}] = \alpha_t + \sum_l \gamma_{tl} \cdot fr_{itl} \quad (5)$$

¹² In a robustness check, we add another firm-specific variable: an insurer's A.M. Best's financial strength rating. Although insurers that are more likely to fulfill their obligations to policyholders can ask for higher rates, holding additional capital is costly, and our analyses do not explicitly account for this cost. To account for this cost, we add insurer AM Best financial strength rating as a regressor in the equations that determine the abnormal realized underwriting returns, both on the insurer level and on the insurer-line level (equations 5-6 and 12-13). We find that accounting for insurer financial strength has little effect on the results.

where the time-varying coefficients, γ_{tl} , reflect the insurer's exposure to line-year-specific effects.

The coefficients α_t and γ_{tl} are estimated by OLS, with ε_{it} being an error term:

$$UWRET_{it} = \alpha_t + \sum_l \gamma_{tl} \cdot fr_{itl} + \varepsilon_{it} \quad (6)$$

Positive values of the abnormal realized underwriting return mean that an insurer's realized underwriting return is better than expected given its business mix, while negative values mean that an insurer performs worse than expected given its business mix.

3.2.2 Consistency of underwriting performance over time after accounting for insurer business mix.

Similar to the consistency measure introduced in the previous section,¹³ we define *AUWRET_CONSISTENCY* to capture the consistency of insurer abnormal underwriting performance over k years:

$$AUWRET_CONSISTENCY_{it} = \begin{cases} CONSISTENT_BETTER & \text{if } AUWRET_{it} \geq 0 \% \text{ in each year between } t - k + 1 \text{ and } t \\ CONSISTENT_WORSE & \text{if } AUWRET_{it} < 0 \% \text{ in each year between } t - k + 1 \text{ and } t \\ INCONSISTENT & \text{otherwise} \end{cases} \quad (7)$$

¹³ A comparison of the two measures of consistency can be found in Appendix B.

where *CONSISTENT_BETTER* (*CONSISTENT_WORSE*) represents consistently achieving superior (subpar) underwriting results, and *INCONSISTENT* is the label for inconsistent performance, all while holding business mix fixed.

Using *AUWRET_CONSISTENCY*, we replicate the analyses from the previous subsection. Again, we report the results based on three-year periods ($k = 3$), but all results hold with $k = 4$ and $k = 5$. If we do not observe consistent differences in firms' underwriting performance after accounting for their business mix, this would suggest that the differences in insurers' underwriting performance are driven by the differences in underwriting profitability across lines of business, rather than by outperforming peers in the same lines.

We begin by comparing the actual yearly proportions of insurers in the *CONSISTENT_BETTER*, *CONSISTENT_WORSE* and *INCONSISTENT* groups with the proportions we would expect under the hypothesis of no differences in underwriting discipline (the expected proportions are obtained from a simulation similar to one in the previous subsection). The results are documented in Figure 4 and Table 3: as before, the actual yearly proportions of insurers in the *INCONSISTENT* group are always below the smallest simulated proportion, while the actual proportions of insurers in the two consistent groups are always greater than the respective maximum simulated values. These results indicate that the observed level of consistency in insurer underwriting performance could not plausibly arise without differences in underwriting discipline, even after accounting for insurer business mix.

[Figure 4]

[Table 3]

Next, we study the persistence of differences in abnormal underwriting performance over time. The results are visualized in Figure 5, with the statistical tests detailed in Table 4. The differences in insurer underwriting performance remain present throughout the sample period even after accounting for insurer business mix. Moreover, the differences between the *CONSISTENT_BETTER* and *CONSISTENT_WORSE* groups, while comparable in magnitude to the differences between the *CONSISTENT_PROFIT* and *CONSISTENT_LOSS* groups, remain significant over longer periods of time. For example, when classified based on 2007-2009, the average insurer in the *CONSISTENT_BETTER* group significantly outperforms the average insurer in the *CONSISTENT_WORSE* group in 11 out of 16 prior years; for reference, the difference between the *CONSISTENT_PROFIT* and *CONSISTENT_LOSS* groups is significant in 9 out of 16 years. Although we do not report the results for other classification periods, this is generally true for any three-year classification period. When classified based on 2001-2003, insurers in the *CONSISTENT_BETTER* group on average significantly outperform insurers in the *CONSISTENT_WORSE* group in all years.

[Figure 5]

[Table 4]

These findings indicate that differences in business mix cannot explain the consistent differences in insurers' underwriting performance identified in subsection 3.1. To the contrary,

accounting for insurer business mix appears to make the differences between insurers even more pronounced.

3.3 Consistency over time: additional robustness checks.

We perform a variety of robustness checks that allow us to document that the consistent differences in insurer underwriting profitability remain present even after we account for the differences in the volatility of underwriting returns across product lines, differences across states, and the impact of firm characteristics. All results reported in this subsection still hold regardless of whether the consistency of underwriting profitability is measured based on three-, four- or five-year periods.

The measure of consistency defined in the previous subsection accounts for the possibility that the *average* return on underwriting varies across product lines and over time; however, it does not directly account for potential differences in the *volatility* of underwriting returns across product lines.¹⁴ In other words, insurers operating in highly volatile lines, such as medical professional liability, may be labeled *INCONSISTENT* more frequently than insurers in less volatile lines, such as auto physical damage. To separate the volatility inherent in product lines from the insurer-specific volatility, we incorporate into the simulation the underlying distributions of underwriting returns in each product line. For example, if an insurer writes three lines in a given year, we draw a random underwriting return for each of these lines and then calculate the insurer's simulated total return on underwriting as a weighted average of the three line-specific returns (the weights for

¹⁴ The measure might account for the differences in the volatility of underwriting returns across product lines indirectly if these differences are reflected in line-average underwriting returns (that is, if the greater risk of more volatile product lines is priced into the coverage).

each insurer are its respective proportions in each line). The consistency of insurers' total simulated returns is then compared with the consistency of their actual returns using the same procedures as described above. The results of this simulation can be found in Appendix C.1 and provide additional evidence that the consistent differences in underwriting profitability among insurers are not driven by their choice of product lines.

A related analysis explores whether consistent differences in insurers' underwriting profitability are apparent within each product line. Following the methodology in subsections 3.1.2 and 3.2.2, we perform a separate simulation for each of the eleven product lines (see footnote 7 for the list of product lines). We find that at the 0.001 significance level, there are consistent differences in insurers' underwriting profitability within every product line. These differences are manifest throughout the sample period from 1991 to 2009. The only exceptions, i.e. outcomes when the observed amount of consistency could plausibly arise due to random luck rather than firm-specific differences, occur in medical professional liability in three-year periods starting from 1999, 2000 and 2002, and special liability in three-year periods starting from 1996–2001. In sum, we find consistent differences in insurers underwriting profitability in over 95% of the line-years in our sample at the 0.001 significance level, which is strong evidence that the observed consistency is not due to insurer decisions about what lines of business to operate.

A potential source of consistency that we have not considered so far is the possibility that the average underwriting profitability varies not only across product lines but also across states. To examine whether the differences across states could explain the consistency in insurers' underwriting profitability, we introduce an alternative definition of the abnormal underwriting return that accounts for the proportions of an insurer's business in each state, product line and year

(e.g. the proportion of an insurer's total premiums written in year t that comes from medical professional liability in Florida). Specifically, we adjust the calculation of the expected realized underwriting return for insurer i in year t in Eq. (4) as follows:

$$E[UWRET_{it} | X_{it}] = \alpha_t + \sum_l \sum_s \gamma_{ls} \cdot fr_{itls} \quad (8)$$

where α_t are year fixed effects and fr_{itls} are the proportions of insurer i 's total premiums written in line l , state s and year t . The coefficients α_t and γ_{tl} are estimated by OLS, with ε_{it} being an error term:

$$UWRET_{it} = \alpha_t + \sum_l \sum_s \gamma_{ls} \cdot fr_{itls} + \varepsilon_{it} \quad (9)$$

Using this definition of the expected underwriting return, we calculate the abnormal realized underwriting return as in Eq. (4) and replicate the simulation and other analyses in subsection 3.2.2. Again, we find strong and lasting differences in insurers' underwriting profitability with similar statistical and economic significance (see Appendices C.2 and C.3 for detailed results). This evidence indicates that neither differences among states nor differences among product lines can explain the consistent differences in underwriting profitability.

An additional robustness check examines whether the consistent differences in underwriting profitability can be explained by differences in observable firm characteristics. We modify the simulation to test whether there are differences in underwriting discipline beyond any potential

effects of organizational form, firm size, and distribution system. We separate insurers every year into buckets depending on their size quartile, organizational form (stock or mutual) and distribution system (direct or independent agent). For each bucket, we calculate the probability of having a positive abnormal realized underwriting return and use these probabilities to simulate from a Bernoulli distribution as described in subsection 3.1.2. We use two definitions of the abnormal realized underwriting return: as defined in subsection 3.2.1, which accounts for insurer product mix, as well as the alternative definition introduced in this subsection, which accounts for both product mix and states (Appendix C.4 reports the results for the more restrictive latter case). In both cases, the simulation rejects the null hypothesis of no differences in underwriting discipline at the 0.0001 level. This evidence indicates that the consistent differences in underwriting profitability are not a result of firm size, organizational form, or distribution system.

The robustness checks demonstrate that the consistent differences in insurers' underwriting profitability remain prominent after we account for differences in the volatility of underwriting returns across product lines, differences in insurer business mix both in terms of product lines and states, and differences in firm size, organizational form and distribution system. The combined evidence strongly suggests differences in underwriting discipline.

3.4 Consistency across product lines.

In this subsection, we study the consistency of an insurer's underwriting performance across its product lines. If an insurer has strong (weak) underwriting discipline as its strategy, then its underwriting results are likely to be strong (weak) in most of the lines it writes. Alternatively, an

insurer may have no overarching strategy or it may pursue growth goals in some lines by subsidizing them with income from its more profitable business segments.

3.4.1 Line-level realized abnormal underwriting return.

To investigate underwriting performance on the insurer-line level, we define the line-level realized underwriting return $UWRET_{itl}$ and abnormal realized underwriting return $AUWRET_{itl}$ obtained by insurer i in year t in line of business l similar to the firm-level variables:

$$UWRET_{itl} = \frac{Premiums_{itl} - PV(DevLosses_{itl}) - UW_Expenses_{itl}}{Premiums_{itl}} \cdot 100\% \quad (10)$$

$$AUWRET_{itl} = UWRET_{itl} - E[UWRET_{itl} | X_{itl}], \quad (11)$$

where $Premiums_{itl}$, $PV(DevLosses_{itl})$ and $UW_Expenses_{itl}$ are net premiums earned, present value of developed losses (incl. loss adjustment expenses) and underwriting expenses incurred in line of business l by insurer i in year t . X_{itl} could be variables pertaining to insurer, line of business, or year. For our analysis, we only use line-year fixed effects, α_{tl} , estimated by OLS, with ε_{itl} being an error term:

$$UWRET_{itl} = \alpha_{tl} + \varepsilon_{itl} \quad (12)$$

$$E[UWRET_{itl} | X_{itl}] = \alpha_{tl}. \quad (13)$$

3.4.2 Setup for line-level analyses.

Studying the relationship between an insurer's overall underwriting performance and its underwriting performance across its product lines requires caution, as the former is composed of the latter (and in the case of single-line insurers, the two are exactly equal). We address this in three ways.

First, we use non-overlapping time periods for insurer-level and insurer-line-level underwriting performance: we classify insurers as *CONSISTENT_BETTER*, *CONSISTENT_WORSE* and *INCONSISTENT* based on their overall underwriting performance in years $t - 3$ through $t - 1$ and then study insurers' line-level underwriting results, $AUWRET_{itl}$, in year t (thus, t ranges from 1994 through 2009).

Second, we aggregate all variables to the group level prior to constructing the ratios of interest; thus, our sample consists of insurance groups and unaffiliated insurers (we refer to both as "insurers" below). This results in a greater number of lines per insurer and greater robustness, as insurance groups may include subsidiaries with varying levels of underwriting discipline as well as recently acquired subsidiaries with a different approach to underwriting.

Third, we limit the sample to insurers that write at least five lines of business.¹⁵

¹⁵ The results are robust to the less restrictive requirement of at least three lines of business, as well as to including even single-line insurers.

3.4.3 Consistency of insurer performance across product lines.

We first compare the general structure of the business mix of insurers with different firm-level underwriting performance. We do not find a strong relationship between an insurer's overall underwriting performance and the number of product lines it writes. The average number of lines equals 7.76 for *CONSISTENT_BETTER* insurers, 7.92 for *CONSISTENT_WORSE* insurers and 7.65 for *INCONSISTENT* insurers. The median number of lines equals 8 for *CONSISTENT_BETTER* and *INCONSISTENT* insurers and 9 for *CONSISTENT_WORSE* insurers.

We then examine the variation in underwriting performance across an insurer's lines of business. All three categories of insurers have considerable variation in line-level underwriting returns, although the line-level results of the *CONSISTENT_BETTER* group are somewhat less disperse than the line-level results of the other two groups. The standard deviation of line-level abnormal realized underwriting return is 22.03, 25.16 and 23.96 percentage points for the average *CONSISTENT_BETTER*, *CONSISTENT_WORSE* and *INCONSISTENT* insurer. The difference in abnormal realized underwriting return of an insurer's best line and worst line is 66.82, 76.13 and 71.87 percentage points for the mean *CONSISTENT_BETTER*, *CONSISTENT_WORSE* and *INCONSISTENT* insurer.

We next investigate the consistency of insurer underwriting performance across lines. An insurer's median-line underwriting performance significantly differs across the three groups: the median-line abnormal realized underwriting return is 5.35%, -4.39% and 0.53% for the average *CONSISTENT_BETTER*, *CONSISTENT_WORSE* and *INCONSISTENT* insurer (all three are significantly different from one another at the 0.05 level, based on a t-test). The proportion of lines

with superior underwriting performance also differs across the three groups: the average *CONSISTENT_BETTER* insurer has superior underwriting performance¹⁶ in 62.72 percent of lines, while the average *CONSISTENT_WORSE* and *INCONSISTENT* insurers have superior underwriting performance in 42.61 and 52.85 percent of lines, respectively (all three are significantly different from one another and from 50 percent at the 0.05 level). Finally, we find that the proportion of insurers that have superior underwriting results in most lines they write also differs significantly across the groups. Table 5 shows that the *majority* of *CONSISTENT_BETTER* insurers have superior underwriting performance in most lines, and the *majority* of *CONSISTENT_WORSE* insurers have worse than average underwriting performance in most lines. Specifically, two-thirds (67.91%) of *CONSISTENT_BETTER* insurers have superior underwriting performance in more than half of the lines they write. Among *CONSISTENT_WORSE* insurers, only 31.17% have superior performance in most lines, but 60.17% have worse than average performance in most lines. Only 23.86% of *CONSISTENT_BETTER* insurers have below-average performance in more than half of the lines they write. Overall, we find that even though the number of lines written and the dispersion in line-level results are similar for the three groups, the strength of line-level underwriting performance differs.

[Table 5]

In an additional (unreported) robustness check, we focus on the 15 biggest U.S. non-life insurance groups and examine their underwriting returns in all the product lines that they write.

¹⁶ Line-level superior underwriting performance is defined as $AUWRET_{itl} \geq 0$.

The insurers are selected based on total premiums written in 2009, the last year of our sample, and for each insurer in each product line we calculate the average of its line-level abnormal underwriting returns in all years between 1991 and 2009 when the insurer writes the line. We find that even among these large, established, multi-line insurers, there is a prominent tendency for underwriting returns in different product lines to be clustered: several insurers have either positive or negative abnormal returns in all or nearly all of their product lines.

The combined evidence in this subsection suggests that the observed differences in underwriting profitability are not driven by a limited number of lines. In fact, the results suggest that an insurer's level of underwriting discipline manifests itself across the product lines it writes.

Chapter 4

Underwriting Discipline and Investment Strategy.

In this section, we explore the relationship between insurers' underwriting discipline and investment strategies. We first construct a measure of underwriting discipline suitable for firm-level analyses. We then examine whether insurers with weaker underwriting discipline take more investment risk and/or attain higher risk-adjusted investment returns than insurers with strong underwriting discipline.

4.1 Firm-level measure of underwriting discipline.

In order to explore the relationship between insurers' underwriting discipline and investment strategies, we use a measure of underwriting discipline that reflects both the strength of an insurer's underwriting performance and its consistency.¹⁷ The measure that we construct, *UWD_CAT*, classifies insurers into four groups: those with consistently strong, medium and weak underwriting performance and inconsistent insurers (we label them as *STRONG*, *MEDIUM*, *WEAK*, and *INCONSISTENT* respectively).

¹⁷ *UWRET_CONSISTENCY* and *AUWRET_CONSISTENCY* are convenient for examining the consistency of underwriting profitability at the industry level but are too restrictive for analyses at the firm level, and they do not distinguish between inconsistent and consistently average underwriting performance. We include these measures in robustness checks.

First, we quantify the strength of an insurer's underwriting performance as the mean of its abnormal realized underwriting returns, μ_{i,t_1,t_2} , and the consistency of its underwriting performance as the standard deviation of its abnormal realized underwriting returns, σ_{i,t_1,t_2} , in years t_1 through t_2 :

$$\mu_{i,t_1,t_2} = \frac{\sum_{\tau=t_1}^{t_2} AUWRET_{i\tau}}{t_2 - t_1 + 1}, \quad (14)$$

$$\sigma_{i,t_1,t_2} = \sqrt{\frac{\sum_{\tau=t_1}^{t_2} (AUWRET_{i\tau} - \mu_{i,t_1,t_2})^2}{t_2 - t_1 + 1}} \quad (15)$$

Second, we determine each insurer's tercile, T_{i,t_1,t_2} , with respect to the strength of underwriting performance in years t_1 through t_2 (μ_{i,t_1,t_2}). For the one third of insurers with the strongest underwriting performance T_{i,t_1,t_2} equals 1, for those in the middle third, $T_{i,t_1,t_2} = 2$, and for the one third of insurers with the weakest underwriting T_{i,t_1,t_2} equals 3.

Third, we set a threshold for the variability of the insurer underwriting performance, σ_{thresh,t_1,t_2} : insurers that have a standard deviation of the abnormal realized underwriting returns (σ_{i,t_1,t_2}) greater than the threshold are categorized as inconsistent, regardless of the strength of their underwriting performance.

$$UWD_CAT_{i,t_1,t_2} = \begin{cases} STRONG & \text{if } \sigma_{i,t_1,t_2} \leq \sigma_{thresh,t_1,t_2} \text{ and } T_{i,t_1,t_2} = 1 \\ MEDIUM & \text{if } \sigma_{i,t_1,t_2} \leq \sigma_{thresh,t_1,t_2} \text{ and } T_{i,t_1,t_2} = 2 \\ WEAK & \text{if } \sigma_{i,t_1,t_2} \leq \sigma_{thresh,t_1,t_2} \text{ and } T_{i,t_1,t_2} = 3 \\ INCONSISTENT & \text{if } \sigma_{i,t_1,t_2} > \sigma_{thresh,t_1,t_2} \end{cases} \quad (16)$$

For the analyses described below, we use five-year windows to calculate μ_{i,t_1,t_2} and σ_{i,t_1,t_2} . We set the consistency threshold σ_{thresh,t_1,t_2} equal to the third quartile of all insurers' σ_{i,t_1,t_2} for the respective five-year window: this results in a similar number of insurers falling into each of the four categories.

In Appendix D, we analyze which insurers have stronger (weaker) underwriting discipline. We find that mutual insurers and insurers affiliated with a group have lower odds of having strong underwriting discipline. Underwriting discipline is positively related with geographical and product line concentration and financial strength, negatively related with insurer size and nonlinearly related with growth and leverage.

4.2 Measures of investment risk.

We use two measures of investment risk. The first measure follows existing studies (Yu et al, 2008; Che and Liebenberg, 2017) and is defined as the percentage of an insurer's assets invested in common stocks and risky bonds:

$$INVRISK_{it} = \frac{CommonStocks_{it} + RiskyBonds_{it}}{InvestedAssets_{it}} \cdot 100\%, \quad (17)$$

where $CommonStocks_{it}$ is the amount invested in common stocks, $RiskyBonds_{it}$ is the amount invested in bonds with NAIC risk categories 4 through 6, and $InvestedAssets_{it}$ is the total amount of invested assets of insurer i in year t .

Our second measure of investment risk is based on the risk-based capital charges that the regulator – the NAIC – assigns to different asset classes. Table 6 lists the charges as well as the sample average percentages of the investment portfolio allocated to different asset classes. The measure represents a weighted-average risk charge for insurer i 's investment portfolio in year t , where the weights are the amounts of investment in each asset class:

$$WINVRISK_{it} = \frac{\sum_{k=1}^K Asset_{kit} \cdot w_k}{\sum_{k=1}^K Asset_{kit}}, \quad (18)$$

where K is the total number of asset classes, w_k is the regulatory capital risk charge (in percent) for asset class k , and $Asset_{kit}$ is the amount of assets allocated by insurer i to class k in year t .

[Table 6]

This measure has a number of advantages: in addition to providing a more holistic characterization of an insurer's investment portfolio and a greater sensitivity to changes in the portfolio composition, the measure accounts for the impact of regulatory capital charges on insurers' portfolio allocation decisions. As documented by Ellul et al. (2011) and Becker and Ivashina (2015), insurers are responsive to regulatory capital charges.

The descriptive statistics for both measures are provided in Table 7. Ninety percent of insurers in our sample hold 0% to 45% of their invested assets in common stocks and risky bonds. The average (median) insurer in our sample allocates 12.59% (7.27%) of its investment portfolio to these assets. The portfolio-weighted risk charge, $WINVRISK_{it}$, ranges from 0.16% to 6.97% for the middle 90% of insurers in our sample. For reference, 0.30% is the risk charge for bonds other than U.S. government bonds designated by the NAIC as “Class 1 – Highest Quality,” and 10% is the risk charge for bonds designated as “Class 5 – Lower Quality.” The average (median) portfolio-weighted risk charge is 2.10 (1.32) percent, which is close to the risk charge of 2% for bonds designated as “Class 3 – Medium Quality.”

[Table 7]

4.3 Industry trends in investment risk taking.

The industry trends in investment risk taking and underwriting profitability over time are shown in Figure 6. (All plots discussed below are similar whether $INVRISK_{it}$ or $WINVRISK_{it}$ is used, therefore we only show the plots using $INVRISK_{it}$, which is arguably easier to interpret.) On the industry level, increases in investment risk generally coincide with periods of declining underwriting profitability. The industry-average percentage of risky assets in the investment portfolio increases from 10.59% in 1994 to 15.06% in 1999, then declines down to 11.96% by 2009. The underwriting profitability exhibits a reverse pattern: the industry-average underwriting return declines in the late 1990s, from 5.89% in 1995 down to -6.93% in 2000, then increases throughout the early 2000s up to 14.04% in 2006.

[Figure 6]

4.4 Underwriting discipline and investment risk taking.

Figures 7 and 8 suggest that the underwriting profitability and investment risk taking are inversely related not only over time but also within the cross-section of insurers.

Figure 7, Panel A compares the investment risk of insurers with *STRONG*, *MEDIUM* and *WEAK* underwriting discipline as well as *INCONSISTENT* insurers. Starting from 1998, insurers with *WEAK* underwriting discipline on average hold a higher percentage of risky assets than insurers with *STRONG* underwriting discipline.

Figure 8 highlights the persistence of the differences in investment risk over time. Using the same methodology as for studying the consistency of underwriting performance, we categorize insurers into *CONSISTENT_BETTER*, *CONSISTENT_WORSE* and *INCONSISTENT* based on their abnormal underwriting performance over a three-year period and then plot each group's mean percentage of risky asset holdings over time.¹⁸ Classified using the period from 2007 to 2009, *CONSISTENT_WORSE* insurers allocate a greater portion of their investment portfolio to risky assets than *CONSISTENT_BETTER* insurers in every year from 1991 to 2009; the difference between the two groups' mean percentage of risky asset holdings ranges from 1.84 to 4.82 percentage points depending on the year. For example, in 1997, ten years prior to the classification period, the average *CONSISTENT_WORSE* insurer allocates 17.19% of its investment portfolio to

¹⁸ Classifying insurers based on their absolute, rather than abnormal, underwriting performance yields similar results. The results are also robust to the choice of the classification period and to comparing the medians instead of the means.

risky bonds and common stocks, while the average *CONSISTENT_BETTER* insurer allocates 12.49% of its investment portfolio to such assets. Table 8 shows that the difference in the two groups' investment risk is statistically significant from 1994 to 2009, or 16 out of 19 years in the sample.

[Figure 7]

[Figure 8]

[Table 8]

We next examine the relationship between an insurer's underwriting discipline and its investment risk in a regression setting. Importantly, we do not make any assumption about the direction of causality: it is likely that these two aspects of an insurer's strategy are determined jointly. While it is possible and likely that there are also causal influences in either direction, the objective of our study is to document the existence of different insurer strategies – a phenomenon that cannot be readily explained by existing theories. The question of why insurers choose one strategy or another is beyond the scope of this paper. The regression framework allows us to document and measure a conditional correlation between the amounts of investment risk and underwriting discipline after accounting for other insurer characteristics. We account for the following insurer characteristics: organizational form, distribution channel, group affiliation, size, diversification, growth, investment strategy, financial strength, leverage, and reinsurance usage.

Table 9 defines each variable and provides descriptive statistics (with additional information about financial strength ratings in Table 10).

[Table 9]

[Table 10]

The inverse relationship between an insurer's underwriting discipline and its investment risk remains prominent after we control for insurer characteristics in the two-way fixed-effects regressions presented in Table 11. Column 1 reports the results for $INVRISK_{it}$. The coefficient on $WEAK$ is 0.94 and statistically significant at the 5% level. Since the average insurer in our sample holds 12.59% of its assets in risky investments, the coefficient on $WEAK$ implies that insurers with weak underwriting discipline hold 7.47% ($0.94\%/12.59\%$) more assets in risky investments than firms with strong underwriting discipline. The coefficient on $MEDIUM$, which is statistically significant at the 5% level, implies that insurers with medium underwriting discipline hold 5.88% more assets in risk investments relative to firms with strong underwriting discipline. Column 2 shows that these findings are robust to the use of an alternative measure of investment risk, $WINVRISK_{it}$, which accounts for regulatory risk-based capital charges. Using this measure, the coefficient on $WEAK$ ($MEDIUM$) is 0.14 (0.11) and statistically significant at the 5% level. The coefficient on $WEAK$ ($MEDIUM$) implies that the asset holdings of insurers with weak (medium) underwriting discipline have a portfolio-weighted risk charge that is 6.67% (5.24%) higher than that of an insurer with strong underwriting discipline.

The combined evidence indicates that insurers with weaker underwriting discipline hold larger portions of their investment portfolios in risky assets. The economic significance of the differences in investment risk taking is considerable despite the fact that insurers face regulatory limits on asset risk classes and the amounts that they can place in any asset class.

[Table 11]

4.5 A measure of risk-adjusted investment performance.

We next analyze whether there is a relationship between underwriting discipline and investment performance on a risk-adjusted basis.

Insurers' investment returns, $INVRET_{it}$, are calculated as the ratio of annual investment income (including realized and unrealized capital gains) to invested assets:

$$INVRET_{it} = \frac{InvIncome_{it} + UnrealCapGains_{it}}{InvestedAssets_{it}} \cdot 100\%, \quad (19)$$

where $InvIncome_{it}$ is the amount of investment income, including realized capital gains, $UnrealCapGains_{it}$ are unrealized capital gains, and $InvestedAssets_{it}$ is the total amount of invested assets of insurer i in year t .

The descriptive statistics in Table 7 show that insurers' investment returns in our sample range from -18.93% to 25.37% , with a mean of 5.58% , a median of 5.45% and a standard deviation of 3.38 percentage points. Ninety percent of observations fall within 1.00% to 10.79% .

We construct risk-adjusted investment returns, RA_INVRET_{it} , as the residuals from OLS regressions of $INVRET_{it}$ accounting for insurers' investment allocations to assets of different types and risk levels as well as the duration of insurer liabilities (accounted for as the percentage of long-tailed lines written by the insurer). A separate regression is run for each year to allow the coefficients to vary by year:

$$INVRET_{it} = \beta_{0t} + \sum_{k=1}^K \beta_{kt} \cdot FrAsset_{kit} + \beta_{K+1,t} \cdot PctLongTail_{it} + \epsilon_{it}, \quad (20)$$

where K is the total number of asset classes, $FrAsset_{kit}$ is the percentage of insurer i 's investment portfolio allocated to asset class k in year t , $PctLongTail_{it}$ is the percentage of long-tail lines written by insurer i , and β_{0t} through $\beta_{K+1,t}$ are time-varying regression coefficients.

The risk-adjusted investment returns are centered at zero and vary from -20.37% to 20.03% , with 90% of all observations falling within -3.39% to 3.72% (Table 7). The standard deviation is 2.36 percentage points.

4.6 Underwriting discipline and risk-adjusted investment risk performance.

Univariate analyses do not reveal any systematic differences in risk-adjusted investment returns for insurers with various levels of underwriting discipline. Figure 7, Panel B shows that the average risk-adjusted returns for insurers with *STRONG*, *MEDIUM* and *WEAK* underwriting discipline, as well as *INCONSISTENT* insurers are similar throughout the sample period. Figure 8 demonstrates there are no clear patterns in the long run as well, and Table 8 shows that the differences are generally not statistically significant.

Regression results reported in Table 11 column 3 also provide little evidence that insurers with weaker underwriting discipline achieve superior investment performance on a risk-adjusted basis

Overall, the results in this section indicate that insurers with weaker underwriting discipline invest more in risky assets but do not achieve superior risk-adjusted investment returns than firms with strong underwriting discipline. These results are in line with the comparative advantage hypothesis: insurers with stronger underwriting discipline benefit from the comparative advantage in raising policyholder-supplied risky debt and limit their risk taking in investments, where insurers are at a disadvantage compared to other financial institutions such as investment funds.

Chapter 5

Conclusion and Discussion.

This dissertation examines the role of insurers' financing strategies in the wide variation in underwriting profitability observed within the U.S. non-life insurance industry every year. Our analyses are based on the idea that differences in underwriting discipline, if they exist, will manifest themselves in insurers' underwriting profitability being more consistent than could be explained by random luck alone. We study two forms of consistency of underwriting profitability: over time and across lines of business.

We begin by testing whether insurers differ with respect to the probability of having underwriting losses and find that in most years, the majority of insurers have a consistent underwriting strategy: either an insurer records underwriting profits year after year or it consistently operates at an underwriting loss. The differences between the two types of insurers persist over time: if we observe that insurer A has three years of underwriting losses in a row and insurer B underwriting profits, then for most three-year periods, we observe that insurer A is more likely to have underwriting losses ten years prior and/or ten years later. The average (and median) difference between the two insurers' realized underwriting returns is economically large: for example, if we categorize the firms based on observed underwriting results in the three year period

from 2001 to 2003, then insurer A's underwriting return is on average 4 to 17 percentage points worse than insurer B's in any year from 1991 to 2009 – which corresponds to 10 to 42 million dollars difference in underwriting income for the average insurer with 244 million dollars in net premiums earned.

Differences in business mix do not explain the persistent differences in underwriting profitability. In fact, after accounting for insurer business mix, the differences in underwriting profitability become even more pronounced. While choosing lines of business wisely plays a role, most insurers that consistently attain underwriting profits do so by outperforming peers in the same lines of business. Moreover, an insurer's level of underwriting discipline tends to be consistent across lines: most multiline insurers with superior (subpar) overall underwriting performance have superior (subpar) underwriting performance in the majority of lines they write.

The results indicate that many insurers consistently attain strong returns from their insurance operations despite the random nature of losses. Others, however, appear to lack underwriting discipline and thereby sacrifice the profitability in the area where insurers have a comparative advantage – raising policyholder-supplied risky debt. Disciplined insurers accept less risk in investments, where insurers' ability to create value is at a comparative disadvantage due to the regulatory and tax environment. Potential differences in investment skill among insurers cannot explain these differences in financing strategy: on a risk-adjusted basis, insurers with weaker underwriting discipline do not achieve superior investment performance.

Appendix A: Replication of Key Findings for the Subsample of Insurers Remaining in the Industry from 1991-2014.

In this appendix, we report the key findings replicated for the subsample of insurers that remain operating in the industry throughout our sample period, 1991-2014 (to construct an insurer's realized underwriting return in 2009, we need to know its developed losses, which are reported in the 2014 annual statement). We include an insurer in this subsample if it is present in the original dataset both in 1991 and 2014. The number of insurers in the subsample varies by year because some firms in some years are excluded due to missing values in the original dataset.

Table A.1 replicates the simulation analysis, and Table A.2 replicates the analysis of persistent differences in insurer underwriting performance over time. The abnormal underwriting returns used in these tables account for insurer business mix (both in terms of product lines and states in which an insurer operates). The simulation accounts for differences in firm size, organizational form and distribution system. Thus, these tables represent the most demanding robustness checks. Similar tables for the full sample are Table C.4 and Table C.3.

Table A.3 replicates the analyses of the relationship between underwriting discipline and investment strategy (the results for the full sample are in Table 11). The average value of

$INVRISK_{it}$, in this subsample is 13.94%, i.e. the average insurer holds 13.94% of its assets in risky investments. The coefficient on *WEAK* implies that insurers with weak underwriting discipline hold 10.90% (1.52%/13.94%) more assets in risky investments than firms with strong underwriting discipline. The coefficient on *MEDIUM*, which is statistically significant at the 5% level, implies that insurers with medium underwriting discipline hold 7.68% more assets in risk investments relative to firms with strong underwriting discipline. Column 2 shows that these findings are robust to the use of an alternative measure of investment risk, $WINVRISK_{it}$, which accounts for regulatory risk-based capital charges. The average value of $WINVRISK_{it}$ in this subsample is 2.30%. Using this measure, the coefficient on *WEAK* (*MEDIUM*) is 0.23 (0.15) and statistically significant at the 5% level. The coefficient on *WEAK* (*MEDIUM*) implies that the asset holdings of insurers with weak (medium) underwriting discipline have a portfolio-weighted risk charge that is 10.00% (6.52%) higher than that of an insurer with strong underwriting discipline.

[Table A.1]

[Table A.2]

[Table A.3]

Appendix B: Comparison of Different Approaches to Categorizing Insurers with respect to Consistency of Their Underwriting Performance.

In this appendix, we compare the classifications of insurers based on two industry-level measures of consistency of underwriting performance: *UWRET_CONSISTENCY* and *AUWRET_CONSISTENCY*.

Table B shows that the two classifications are similar but not identical. Among the insurers with consistent underwriting profits, 64% consistently outperform competitors with similar business mix, while one quarter are inconsistent after accounting for the business mix. As for insurers that consistently record underwriting losses, 72% of those also perform consistently worse than expected given their business mix, while one third are inconsistent in terms of their abnormal realized underwriting return. Conversely, 83% of firms with consistently superior underwriting performance given their business mix also consistently obtain underwriting profits, while 53% of insurers with consistently worse than average results in their lines also consistently lose money on underwriting. These results highlight that for most insurers, the path to underwriting profits lies with focusing on strong underwriting skills, rather than with cherry-picking lines of business. This

indicates that differences in business mix cannot explain the consistent differences in underwriting performance.

[Table B]

Appendix C: Testing for Consistency over Time – Alternative Specifications.

C.1 Accounting for differences in the volatility of underwriting returns across product lines.

[Table C.1]

C.2 Accounting for states as well as product lines.

[Table C.2]

[Table C.3]

C.3 The impact of insurer characteristics.

[Table C.4]

Appendix D: The Relationship between Underwriting Discipline and Firm Characteristics.

In this appendix, we explore the relationship between underwriting discipline and insurer characteristics. We consider the following insurer characteristics: organizational form, distribution channel, group affiliation, size, diversification, growth, investment strategy, financial strength, leverage, and reinsurance usage. Table 9 defines each variable and provides descriptive statistics. Differences in organizational form have been linked with varying levels of monitoring and different incentives (see, e.g., Mayers and Smith, 1988). The relationship between underwriting discipline and the distribution channel could go in either direction: insurers that rely on independent agents usually incur higher expenses than direct writers (Joskow, 1973; Berger, Cummins, and Weiss, 1997), but at the same time independent agents may be able to add value through matching customers of various risk types to insurers with different underwriting strategies (Regan and Tennyson, 1996). Larger insurers could benefit from economies of scale and less volatile underwriting performance; at the same time, larger insurers, as well as affiliated and well-diversified insurers could have greater flexibility in terms of their underwriting strategy. Financially stronger insurers might be able to charge higher rates (Cummins and Sommer, 1996; Phillips, Cummins, and Allen, 1998). Stagnant premium growth could prompt insurers to relax their underwriting standards but excessive growth also could indicate insufficient underwriting discipline (Harrington and Danzon, 1994). Financial leverage could reflect insurer goals but at the

same it could affect insurer incentives. Investment strategy can be related with underwriting strategy, as investment and underwriting are two principal sources of insurer income; thus, insurers that expect higher investment income could have lower underwriting discipline.

In our sample, approximately three quarters of insurers are stock and one quarter are mutual insurers; 79% of insurers use independent agents; and 75% are affiliated with a group. The average insurer has product line (geographical) diversification of 0.46 (0.52), with a standard deviation equal to 0.32 (0.38). AM Best financial strength rating, described in more detail in Table 8, varies from A++ (14, “Superior”) to C- (3, “Weak”); the median rating is A (12, “Excellent”). The average (median) insurer cedes 38% (33%) of direct premiums earned to reinsurers; the standard deviation is 27 percentage points. The average (median) insurer has a growth rate in net premiums written equal to 7% (5%), with the standard deviation of 25 percentage points. Leverage, measured as the ratio of net premiums written to policyholder surplus, is on average 1.18 (median is 1.07, standard deviation is 0.73).

Table D.1 reports the average values of firm characteristics at the end of year t by level of underwriting discipline UWD_CAT measured over the next five years ($t+1$ through $t+5$).

[Table D.1]

We use multinomial logistic regression with year fixed effects to study what insurer characteristics are associated with the different levels of underwriting discipline. To avoid potential endogeneity issues, we examine the relationship between insurer characteristics at the end of year t with its underwriting discipline UWD_CAT measured over the next five years ($t+1$

through $t+5$). For example, if we measure underwriting discipline based on insurer underwriting performance during 2001-2005, we use the firm characteristics at the end of 2000. Our regression thus shows what level of underwriting discipline can be expected for an insurer with a given set of characteristics.

Table D.2 reports the results. The base outcome is set equal to *STRONG* and stock insurers are used as the base level for organizational form.

[Table D.2]

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Zanjani, G., 2002, Pricing and Capital Allocation in Catastrophe Insurance. *Journal of Financial Economics*, 65(2), 283-305

Figure 1 – Distribution of the realized underwriting returns, by year.

The figure shows the distribution of realized underwriting returns by year. The realized underwriting return is the difference between the total premiums and the present value of developed losses and underwriting expenses incurred, divided by total premiums. The upper and lower edges of each box represent the 75th and 25th percentiles of the distribution and the bar in the middle the median. The whiskers show the range between the 5th and 95th percentiles, while the dots represents insurers whose realized underwriting return falls outside this range (up to the 1st and 99th percentile)

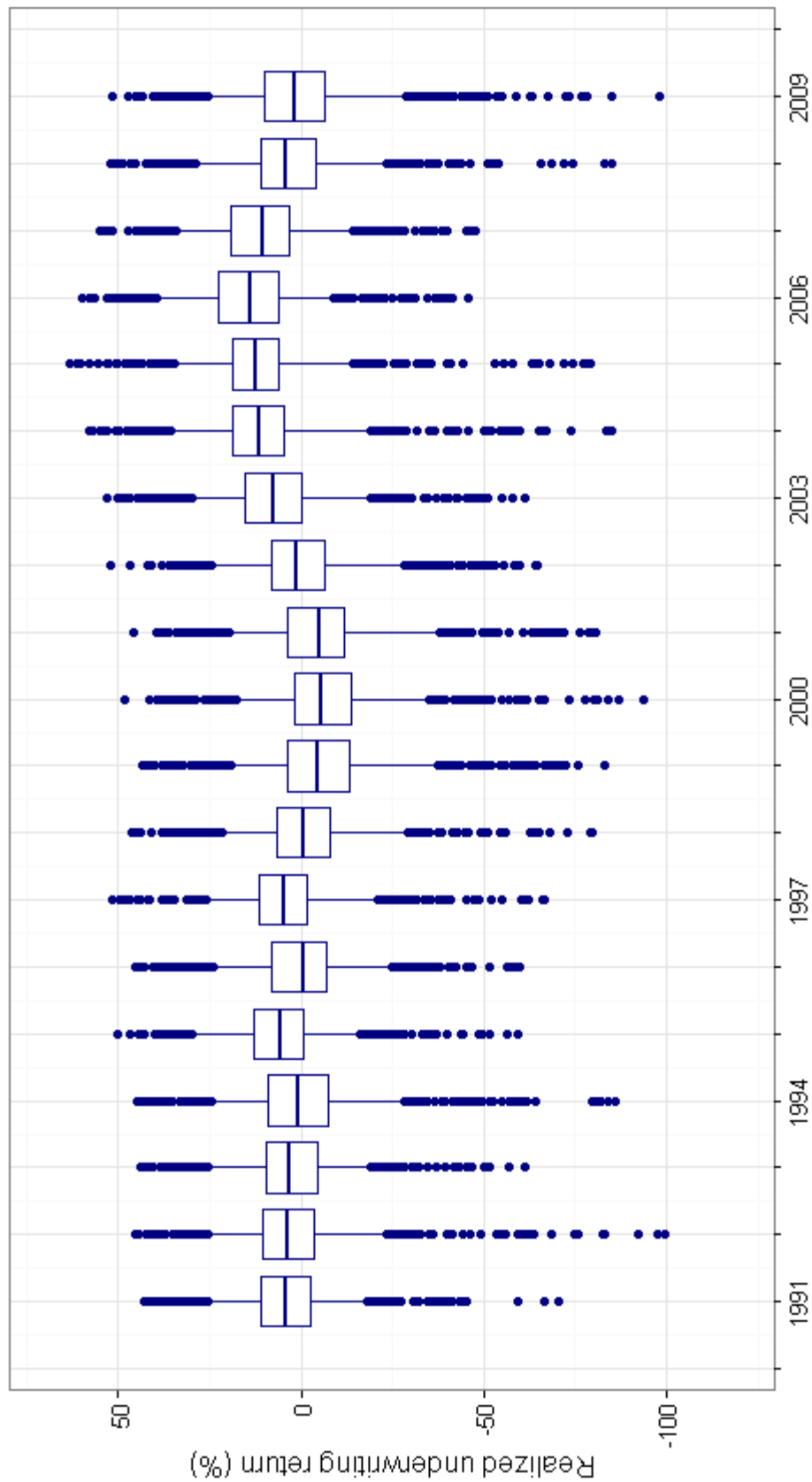


Figure 2 – Annual proportions of insurers with consistent and inconsistent underwriting performance

The top (blue) area represents insurers classified as *CONSISTENT_PROFIT*, the middle (grey) area represents *INCONSISTENT* insurers, and the bottom (red) area represents *CONSISTENT_LOSS* insurers. Insurers are classified as *CONSISTENT_PROFIT* (*CONSISTENT_LOSS*) in year t if they have underwriting profits (losses) each year over a three-year period from $t - 2$ to t . Insurers are classified as *INCONSISTENT* if they have underwriting profits and losses in different years over the three-year period. Panel A shows the actual proportions of U.S. P/L insurers falling into each category. Panel B shows what proportion of insurers we would expect fall into each category if insurers did not differ with respect to underwriting discipline (specifically, if all insurers had the same probability of underwriting gains (or losses)).

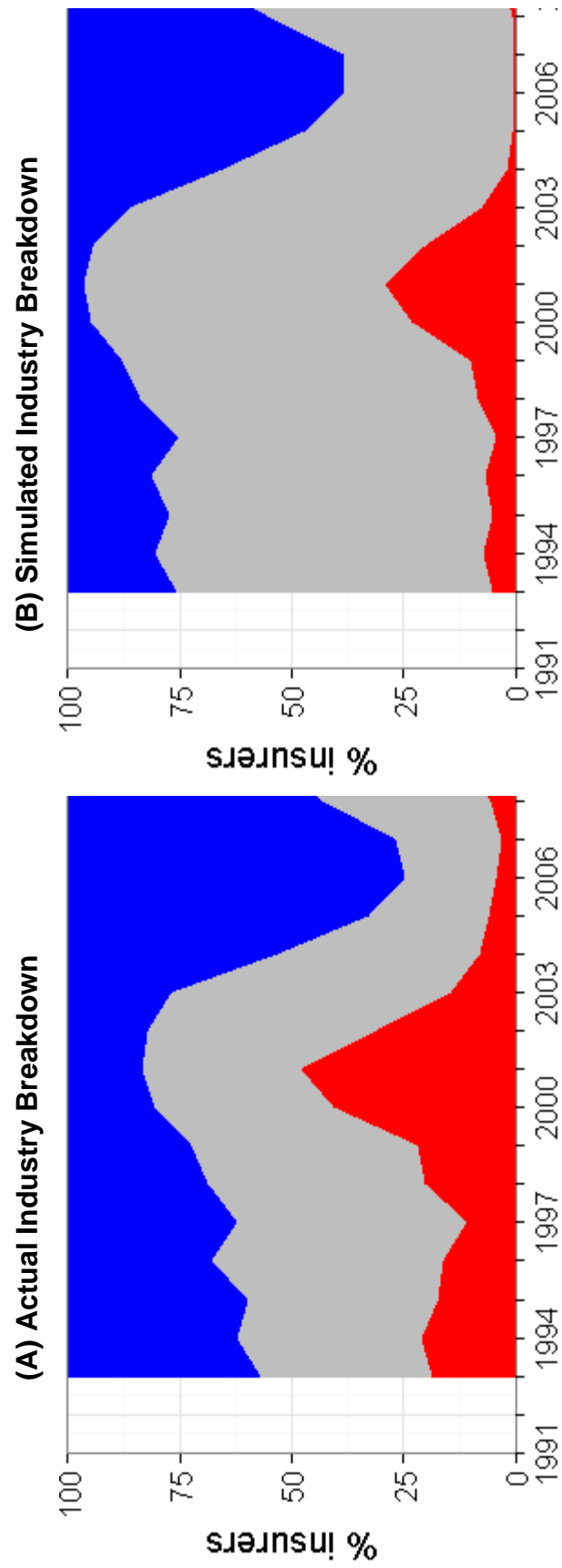


Figure 3 – Persistence of differences in insurer underwriting performance over time.

Insurers are categorized into *CONSISTENT_PROFIT* (blue, filled circle), *CONSISTENT_LOSS* (red, hollow circle), or *INCONSISTENT* (grey, no circle) based on their underwriting performance in the three-year period from 2007-2009 (left column) or 2001-2003 (right column). The top row shows each group's mean realized underwriting return (*UWRET*). The bottom row shows the percentage of insurers that attain underwriting profits each year.

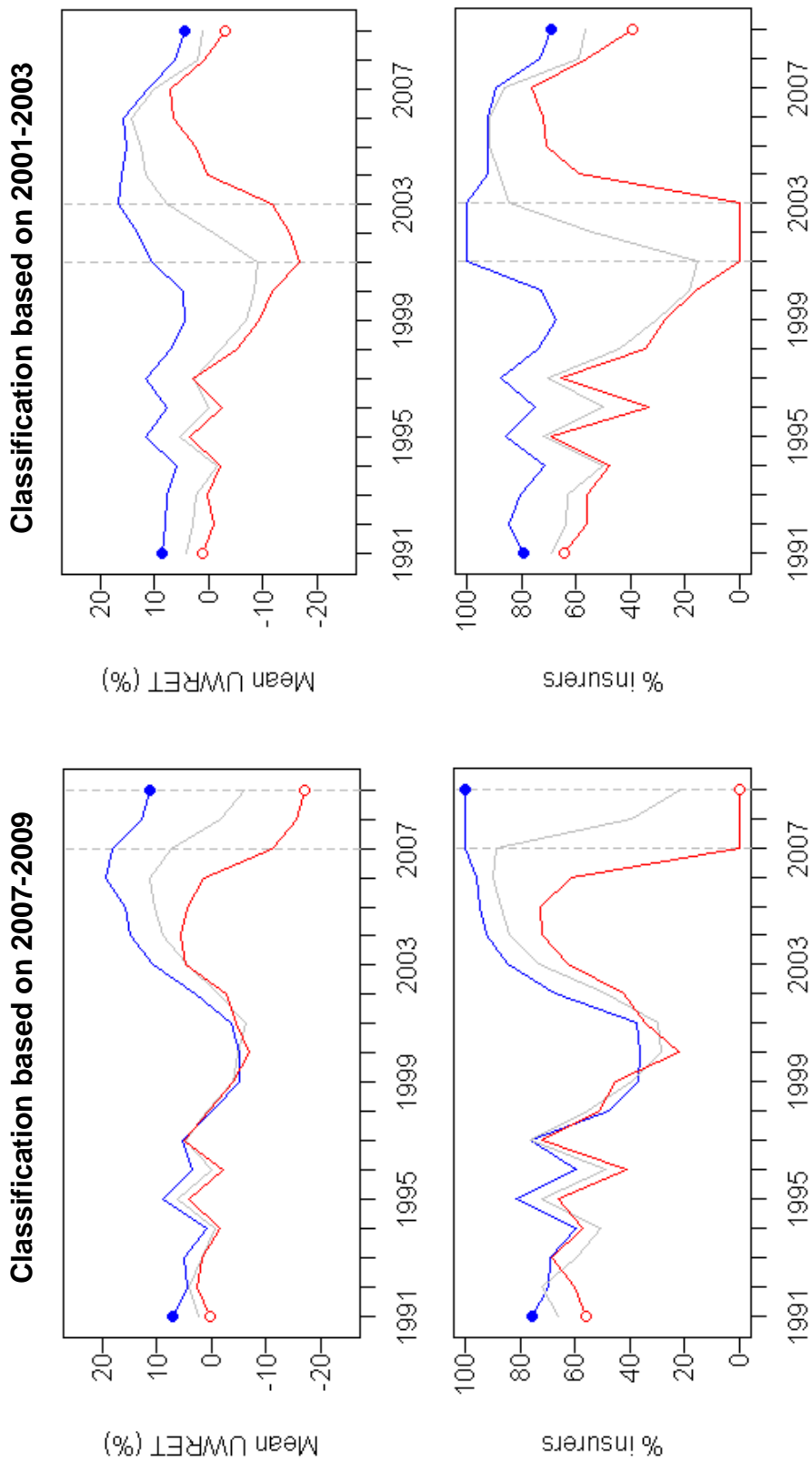


Figure 4 – Annual proportions of insurers with consistent underwriting performance (after accounting for the business mix)

The top (blue) area represents insurers classified as *CONSISTENT_BETTER*, the middle (grey) area represents *INCONSISTENT* insurers, and the bottom (red) area represents *CONSISTENT_WORSE* insurers. Insurers are classified as *CONSISTENT_BETTER* (*CONSISTENT_WORSE*) in year t if their realized underwriting return is always better (worse) than predicted for their business mix over the three-year period from $t - 2$ through t . Insurers are classified as *INCONSISTENT* if their realized underwriting return is better and worse than predicted in different years over the three-year period. Panel A shows the actual proportions of U.S. P/L insurers falling into each category. Panel B shows what proportion of insurers we would expect to fall into each category if insurers did not differ with respect to underwriting discipline (specifically, if all insurers had the same probability of above-average (below-average) underwriting results, holding business mix constant).

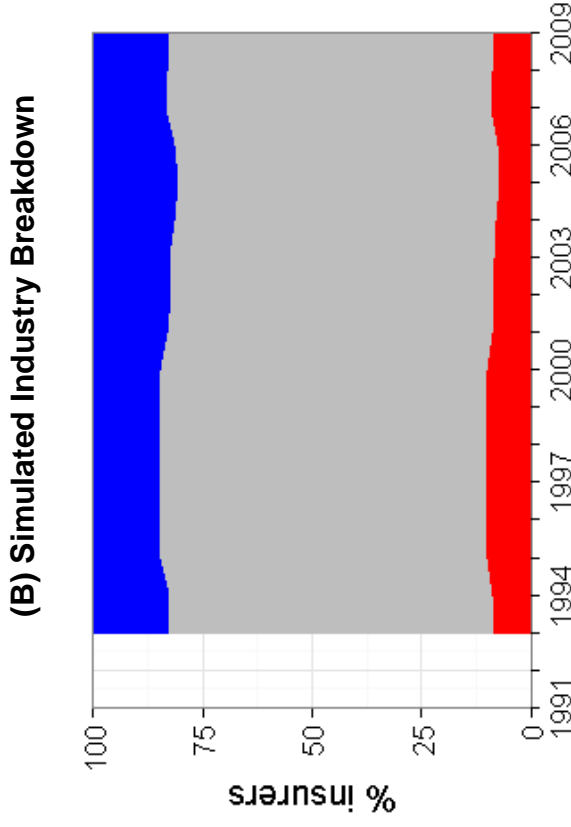
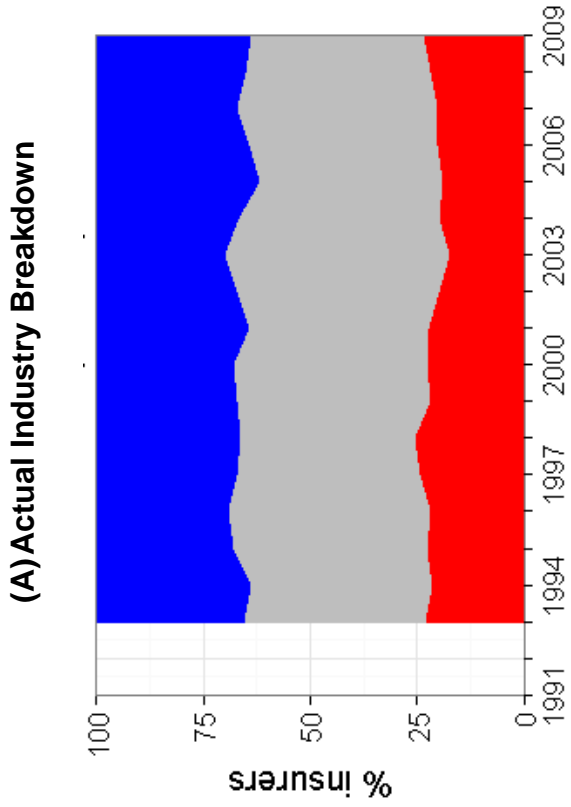
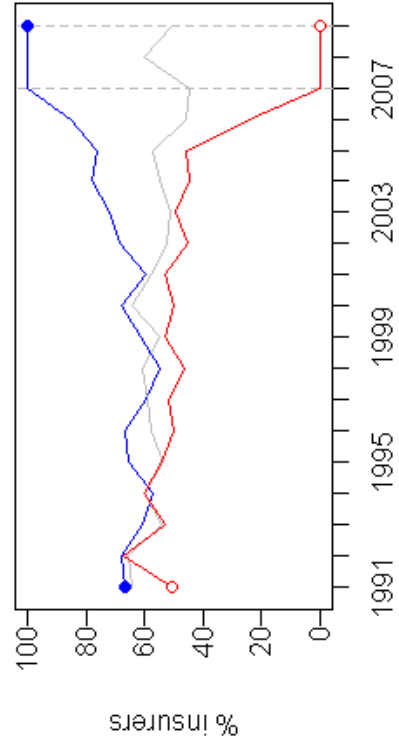
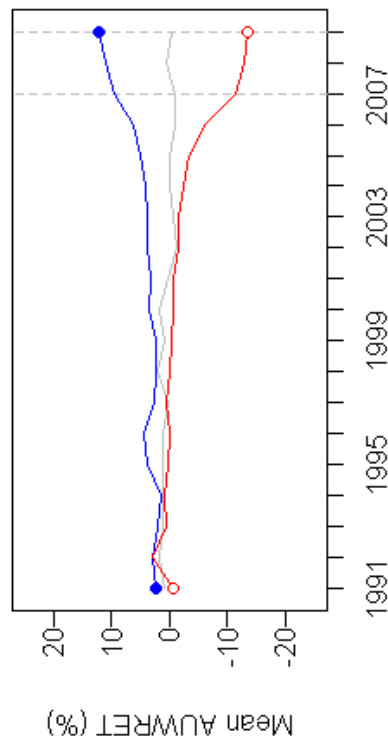


Figure 5 – Persistence of differences in insurer underwriting performance over time (after accounting for the business mix).

Insurers are categorized into *CONSISTENT_BETTER* (blue, filled circle), *CONSISTENT_WORSE* (red, hollow circle), *CONSISTENT_WORSE* (red, hollow circle), or *INCONSISTENT* (grey, no circle) based on their abnormal realized underwriting return (*AUWRET*) in 2007-2009 (left column) or 2001-2003 (right column). The top row shows each group's mean *AUWRET*. The bottom row shows the percentage of insurers that attain a positive *AUWRET* (i.e. better than expected given their business mix) in a given year.

Classification based on 2007-2009



Classification based on 2001-2003

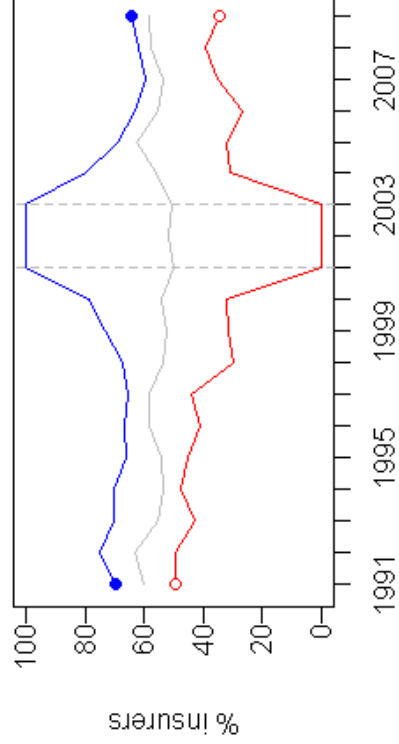
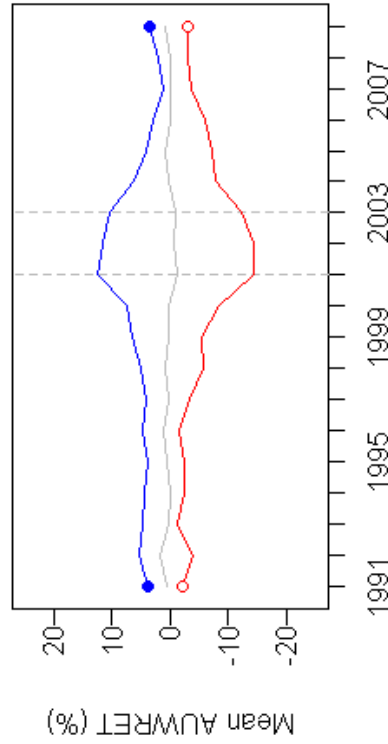


Figure 6 – Industry trends in underwriting profitability and investment risk taking.

UWRET is the industry-average return on underwriting. *INVRISK* is a measure of investment risk; it is calculated as the percentage of assets invested in common stocks and risky bonds.

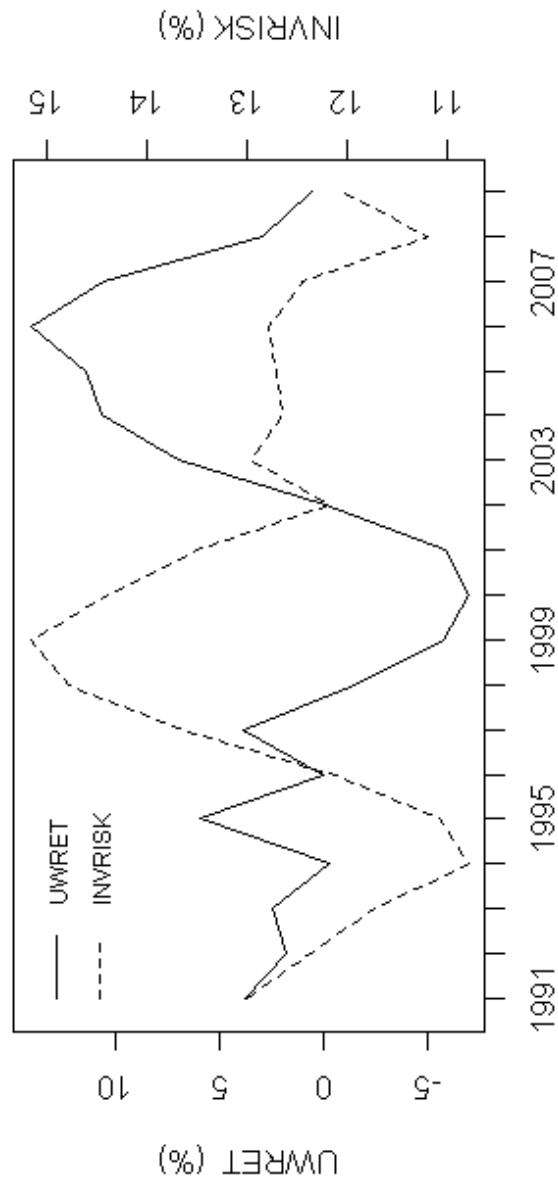
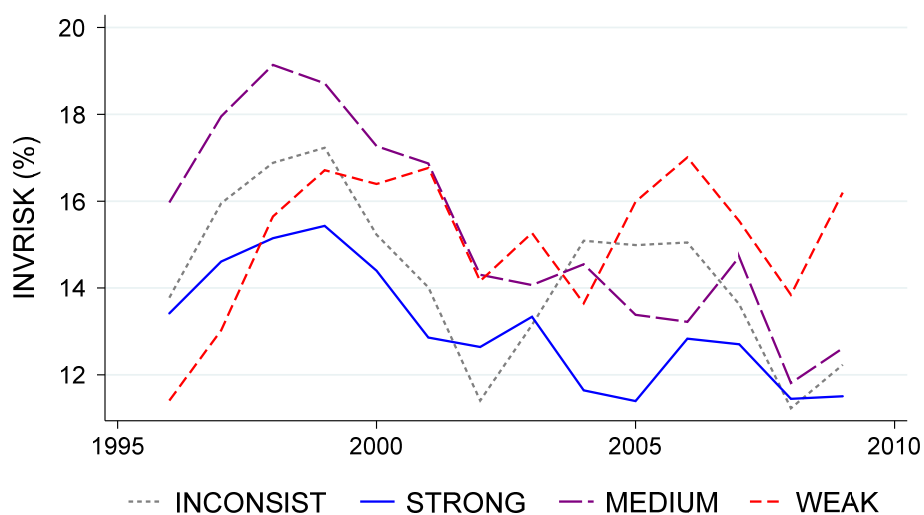


Figure 7 – Investment risk and returns, by the level of underwriting discipline.

INVRISK is a measure of investment risk, defined as the percentage of assets invested in common stocks and risky bonds. *RA_INVRET* are the risk- and duration-adjusted investment returns. Insurers are categorized as having *STRONG*, *MEDIUM* or *WEAK* underwriting discipline or as *INCONSISTENT* based on their underwriting performance over the five-year period from $t-5$ to $t-1$. *INVRISK* and *RA_INVRET* are the mean values for each group in year t .

(A) Investment risk



(B) Investment returns, on a risk-adjusted basis

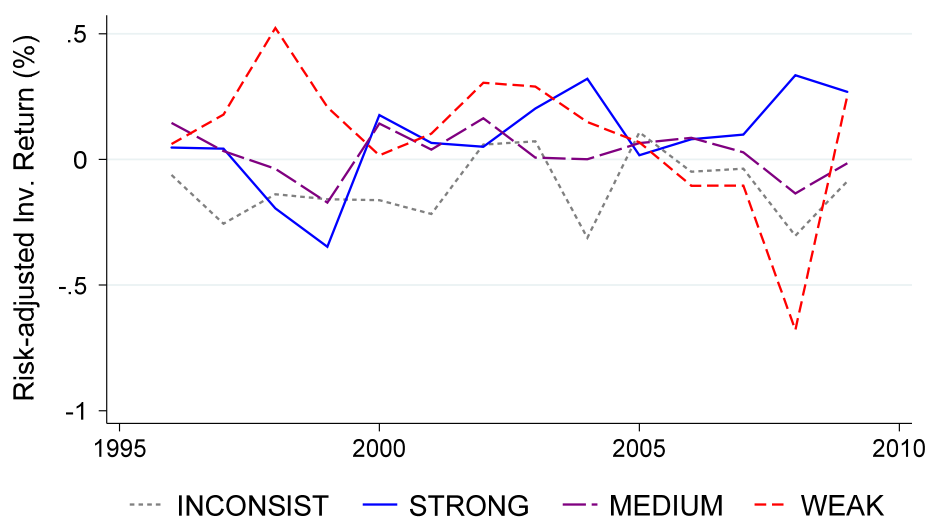


Figure 8 – Investment risk and return, by the level of underwriting discipline.

Insurers are categorized into *CONSISTENT_BETTER* (blue, filled circle), *CONSISTENT_WORSE* (red, hollow circle), or *INCONSISTENT* (grey, no circle) based on their abnormal realized underwriting returns in the period from 2007 to 2009 (left) or 2001 to 2003 (right). The top row shows the each group's average investment risk, *INV_RISK*, measured as the percentage of assets invested in common stocks and risky bonds. The bottom row shows each group's average risk-adjusted investment returns (*RA_INVRET*).

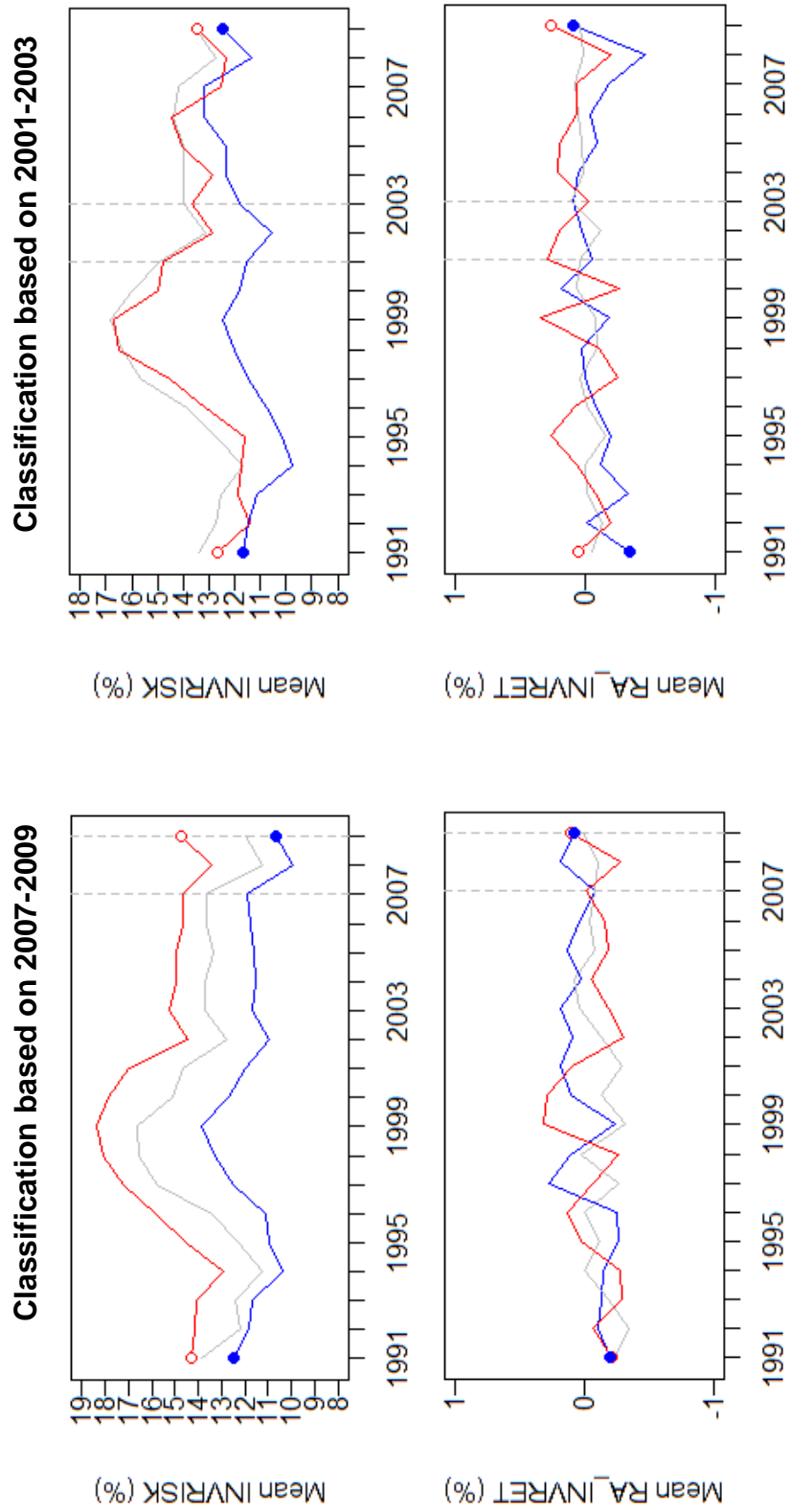


Table 1 – Actual vs. simulated proportions of insurers with consistent and inconsistent underwriting performance.

Insurers classified in year t as *CONSISTENT_PROFIT* or *CONSISTENT_LOSS* have respectively underwriting profits only or underwriting losses only over the three-year period from $t - 2$ through t , while *INCONSISTENT* insurers have both. The columns labeled “Actual” show the actual proportions of U.S. P/L insurers falling into each category. The columns labeled “Simulated” report the results of the simulation designed to estimate what proportion of insurers would fall into each category if insurers did not differ with respect to underwriting discipline (specifically, if all insurers had the same probability of underwriting losses). The simulation generates 10,000 realizations for each annual proportion; columns “Mean”, “Min” and “Max” report the average as well as the smallest and the largest of these realizations for each category each year. For example, 42.89 % of insurers are classified as *CONSISTENT_PROFIT* in 1993, meaning that they have underwriting profits only in each year from 1991 to 1993. The simulation predicts that only 19.40 to 29.33 % of insurers could fall into this category in 1993 if all insurers had the same probability of underwriting losses; under this hypothesis, the best guess for the proportion of insurers in this category would be 24.14 %.

| Year | N firms | Proportion of insurers (%) | | | | | | | | | | | | | | | | | |
|------|---------|----------------------------|-------|-----------|-------|--------|-------|------------------------|-------|--------|-------|-----------|-------|---------------------|-----|-----------|--|--|--|
| | | <i>CONSISTENT_PROFIT</i> | | | | | | <i>CONSISTENT_LOSS</i> | | | | | | <i>INCONSISTENT</i> | | | | | |
| | | Actual | | Simulated | | Actual | | Simulated | | Actual | | Simulated | | Actual | | Simulated | | | |
| Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | | | | |
| 1993 | 907 | 42.89 | 19.40 | 24.14 | 29.33 | 18.41 | 2.87 | 5.32 | 8.27 | 38.70 | 64.94 | 70.55 | 75.96 | | | | | | |
| 1994 | 944 | 37.71 | 15.15 | 19.48 | 24.05 | 21.19 | 4.03 | 7.28 | 10.38 | 41.10 | 67.58 | 73.23 | 78.18 | | | | | | |
| 1995 | 921 | 40.39 | 17.05 | 22.70 | 28.99 | 17.48 | 2.39 | 5.32 | 8.14 | 42.13 | 65.26 | 71.99 | 77.85 | | | | | | |
| 1996 | 948 | 32.17 | 13.50 | 18.70 | 24.26 | 16.24 | 4.01 | 6.69 | 10.23 | 51.58 | 68.67 | 74.61 | 80.38 | | | | | | |
| 1997 | 955 | 37.91 | 19.90 | 24.57 | 30.47 | 10.99 | 2.20 | 4.35 | 6.81 | 51.10 | 64.19 | 71.08 | 76.02 | | | | | | |
| 1998 | 877 | 31.13 | 11.52 | 16.09 | 21.21 | 20.41 | 4.79 | 8.22 | 12.20 | 48.46 | 69.90 | 75.70 | 80.84 | | | | | | |
| 1999 | 849 | 27.56 | 7.77 | 12.17 | 17.20 | 22.03 | 6.48 | 10.12 | 14.37 | 50.41 | 71.38 | 77.71 | 82.92 | | | | | | |
| 2000 | 804 | 19.28 | 2.61 | 5.35 | 8.58 | 40.55 | 17.41 | 23.01 | 29.10 | 40.17 | 65.80 | 71.64 | 77.74 | | | | | | |
| 2001 | 832 | 16.47 | 1.44 | 3.72 | 6.49 | 47.84 | 22.48 | 29.30 | 35.82 | 35.70 | 60.70 | 66.98 | 72.84 | | | | | | |
| 2002 | 872 | 17.66 | 3.10 | 5.66 | 9.40 | 31.08 | 15.60 | 20.40 | 25.80 | 51.26 | 67.89 | 73.94 | 79.93 | | | | | | |
| 2003 | 977 | 23.03 | 9.62 | 13.77 | 18.83 | 14.43 | 4.61 | 7.52 | 10.54 | 62.54 | 73.69 | 78.71 | 83.32 | | | | | | |
| 2004 | 972 | 46.91 | 28.40 | 34.63 | 40.43 | 7.92 | 0.51 | 1.92 | 4.01 | 45.16 | 57.41 | 63.45 | 69.24 | | | | | | |
| 2005 | 986 | 67.34 | 46.25 | 52.87 | 58.42 | 5.88 | 0.00 | 0.62 | 1.83 | 26.77 | 40.67 | 46.51 | 52.94 | | | | | | |
| 2006 | 994 | 75.35 | 55.63 | 61.94 | 67.20 | 4.43 | 0.00 | 0.31 | 1.11 | 20.22 | 32.29 | 37.75 | 43.96 | | | | | | |
| 2007 | 997 | 73.42 | 55.97 | 61.88 | 67.50 | 3.11 | 0.00 | 0.32 | 1.20 | 23.47 | 32.20 | 37.81 | 43.53 | | | | | | |
| 2008 | 969 | 56.97 | 38.29 | 44.69 | 50.88 | 5.47 | 0.00 | 0.84 | 2.17 | 37.56 | 48.30 | 54.46 | 60.17 | | | | | | |
| 2009 | 951 | 46.90 | 22.08 | 28.52 | 33.65 | 10.41 | 0.84 | 2.91 | 5.26 | 42.69 | 63.20 | 68.57 | 75.29 | | | | | | |

Table 2 – Persistence of differences in insurer underwriting performance over time.

Insurers are categorized into *CONSISTENT_PROFIT* and *CONSISTENT_LOSS* based on their underwriting performance in 2007-2009 (Panel A) or 2001-2003 (Panel B). The table shows each group's mean and median realized underwriting returns (*UWRET*), in percent. The table also shows the percentage of insurers that attain underwriting profits in a given year. Differences in the mean (median) *UWRET* between the two groups are determined by a *t*-test (Wilcoxon rank sum test). Differences in the percentage of insurers that record underwriting profits in each year are determined by a chi-square test.

Panel A: Classification Based on 2007 to 2009

| Year | (a) <i>CONSISTENT_PROFIT</i> | | | | (b) <i>CONSISTENT_LOSS</i> | | | | Diff.: (a) - (b) | | | |
|------|------------------------------|-------|--------|--------|----------------------------|--------|--------|-------|------------------|-----------|------------|---|
| | N | Mean | Median | % | N | Mean | Median | % | Mean | Median | | % |
| 1991 | 237 | 7.18 | 6.89 | 75.53 | 52 | 0.32 | 1.53 | 55.77 | 6.86 *** | 5.35 *** | 19.76 *** | |
| 1992 | 261 | 4.37 | 5.61 | 69.73 | 55 | 2.64 | 4.33 | 60.00 | 1.73 | 1.28 | 9.73 | |
| 1993 | 267 | 4.99 | 5.18 | 69.29 | 57 | 1.84 | 3.47 | 68.42 | 3.15 * | 1.70 | 0.87 | |
| 1994 | 286 | 1.01 | 2.62 | 59.44 | 61 | -1.50 | 1.80 | 57.38 | 2.51 | 0.82 | 2.06 | |
| 1995 | 305 | 9.01 | 8.41 | 81.64 | 65 | 4.11 | 3.31 | 66.15 | 4.91 *** | 5.11 *** | 15.49 *** | |
| 1996 | 309 | 3.49 | 3.12 | 59.22 | 66 | -2.06 | -1.87 | 40.91 | 5.55 *** | 4.99 *** | 18.31 *** | |
| 1997 | 304 | 5.38 | 5.53 | 76.32 | 64 | 4.92 | 6.36 | 71.88 | 0.45 | -0.83 | 4.44 | |
| 1998 | 322 | -0.13 | -0.86 | 47.83 | 70 | 0.44 | 0.37 | 51.43 | -0.57 | -1.24 | -3.60 | |
| 1999 | 342 | -5.14 | -4.88 | 36.55 | 75 | -3.80 | -0.54 | 45.33 | -1.34 | -4.34 | -8.78 | |
| 2000 | 330 | -5.06 | -4.19 | 36.36 | 63 | -6.74 | -5.43 | 22.22 | 1.68 | 1.24 | 14.14 ** | |
| 2001 | 366 | -3.56 | -3.52 | 37.43 | 72 | -4.36 | -2.70 | 34.72 | 0.79 | -0.81 | 2.71 | |
| 2002 | 372 | 2.90 | 3.99 | 67.20 | 73 | -2.58 | -1.25 | 42.47 | 5.48 *** | 5.24 *** | 24.74 *** | |
| 2003 | 380 | 10.65 | 11.64 | 84.47 | 80 | 4.87 | 5.20 | 62.50 | 5.78 *** | 6.44 *** | 21.97 *** | |
| 2004 | 384 | 14.87 | 14.13 | 92.19 | 79 | 5.52 | 6.63 | 72.15 | 9.35 *** | 7.50 *** | 20.04 *** | |
| 2005 | 392 | 15.90 | 15.96 | 94.39 | 87 | 4.39 | 8.23 | 72.41 | 11.51 *** | 7.73 *** | 21.97 *** | |
| 2006 | 424 | 19.19 | 18.05 | 95.99 | 88 | 1.41 | 1.92 | 61.36 | 17.78 *** | 16.12 *** | 34.63 *** | |
| 2007 | 434 | 18.17 | 15.77 | 100.00 | 96 | -10.99 | -7.91 | 0.00 | 29.16 *** | 23.67 *** | 100.00 *** | |
| 2008 | 434 | 12.79 | 9.39 | 100.00 | 96 | -15.37 | -12.35 | 0.00 | 28.16 *** | 21.74 *** | 100.00 *** | |
| 2009 | 434 | 11.30 | 9.14 | 100.00 | 96 | -16.91 | -14.19 | 0.00 | 28.21 *** | 23.33 *** | 100.00 *** | |

Panel B: Classification Based on 2001 to 2003

| Year | (a) CONSISTENT_PROFIT | | | | (b) CONSISTENT_LOSS | | | | Diff.: (a) - (b) | | | |
|------|-----------------------|-------|--------|--------|---------------------|--------|--------|-------|------------------|-----------|------------|---|
| | UWRET | | | | UWRET | | | | UWRET | | | |
| | N | Mean | Median | % | N | Mean | Median | % | Mean | Median | Mean | % |
| 1991 | 114 | 8.75 | 7.95 | 78.95 | 81 | 1.04 | 3.55 | 64.20 | 7.71 *** | 4.40 *** | 14.75 ** | |
| 1992 | 130 | 8.10 | 7.01 | 84.62 | 89 | -0.78 | 1.92 | 56.18 | 8.89 *** | 5.09 *** | 28.44 *** | |
| 1993 | 136 | 7.80 | 7.55 | 80.15 | 95 | 0.41 | 2.49 | 55.79 | 7.39 *** | 5.06 *** | 24.36 *** | |
| 1994 | 148 | 5.95 | 8.18 | 71.62 | 101 | -2.23 | -0.24 | 47.52 | 8.18 *** | 8.42 *** | 24.10 *** | |
| 1995 | 159 | 11.52 | 11.59 | 85.53 | 106 | 3.65 | 4.85 | 68.87 | 7.88 *** | 6.74 *** | 16.67 *** | |
| 1996 | 167 | 7.61 | 6.63 | 74.85 | 109 | -2.43 | -3.32 | 33.03 | 10.04 *** | 9.95 *** | 41.82 *** | |
| 1997 | 167 | 11.55 | 10.47 | 87.43 | 109 | 2.83 | 3.74 | 65.14 | 8.72 *** | 6.73 *** | 22.29 *** | |
| 1998 | 175 | 7.01 | 6.91 | 73.71 | 113 | -5.00 | -3.13 | 34.51 | 12.01 *** | 10.04 *** | 39.20 *** | |
| 1999 | 193 | 4.46 | 3.21 | 67.36 | 121 | -9.25 | -7.44 | 27.27 | 13.71 *** | 10.65 *** | 40.08 *** | |
| 2000 | 192 | 4.75 | 4.22 | 72.40 | 114 | -11.77 | -8.49 | 15.79 | 16.52 *** | 12.71 *** | 56.61 *** | |
| 2001 | 219 | 10.33 | 7.46 | 100.00 | 136 | -16.60 | -12.57 | 0.00 | 26.93 *** | 20.03 *** | 100.00 *** | |
| 2002 | 219 | 13.15 | 10.44 | 100.00 | 136 | -14.95 | -10.14 | 0.00 | 28.11 *** | 20.58 *** | 100.00 *** | |
| 2003 | 219 | 16.56 | 14.63 | 100.00 | 136 | -11.57 | -6.56 | 0.00 | 28.14 *** | 21.19 *** | 100.00 *** | |
| 2004 | 201 | 16.17 | 16.03 | 92.04 | 126 | 0.18 | 3.53 | 58.73 | 15.99 *** | 12.49 *** | 33.31 *** | |
| 2005 | 199 | 15.09 | 14.24 | 92.46 | 119 | 2.32 | 6.04 | 70.59 | 12.77 *** | 8.20 *** | 21.87 *** | |
| 2006 | 200 | 15.88 | 15.05 | 92.50 | 117 | 6.38 | 7.59 | 71.79 | 9.50 *** | 7.45 *** | 20.71 *** | |
| 2007 | 197 | 11.25 | 12.26 | 89.34 | 106 | 7.14 | 6.14 | 76.42 | 4.11 ** | 6.12 *** | 12.93 *** | |
| 2008 | 186 | 6.11 | 6.83 | 73.12 | 102 | 0.77 | 1.68 | 55.88 | 5.34 *** | 5.15 *** | 17.24 *** | |
| 2009 | 175 | 4.30 | 5.96 | 69.14 | 99 | -2.91 | -2.79 | 39.39 | 7.21 *** | 8.74 *** | 29.75 *** | |

Table 3 – Actual vs. simulated proportions of insurers with consistent and inconsistent underwriting performance (after accounting for the business mix)

Insurers are classified as *CONSISTENT_BETTER* (*CONSISTENT_WORSE*) in year t as if their realized underwriting return is always better (worse) than predicted for their business mix over the three-year period from $t - 2$ through t , and as *INCONSISTENT* otherwise. The columns labeled “Actual” show the actual proportions of U.S. P/L insurers in each category. The columns labeled “Simulated” report the results of a simulation designed to estimate what proportion of insurers would fall into each category if insurers did not differ with respect to underwriting discipline (specifically, if all insurers had the same probability of below-average underwriting results, holding business mix constant). The simulation generates 10,000 realizations for each annual proportion; columns “Mean” and “Max” report the average as well as the smallest and the largest of these realizations for each category each year. For example, 34.51 % of insurers are classified as *CONSISTENT_BETTER* in 1993, meaning that they always earn positive abnormal returns on underwriting in each year from 1991 to 1993. The simulation predicts that only 12.90 to 23.59 % of insurers could fall into this category in 1993 if all insurers had the same probability of underwriting losses; under this hypothesis, the best guess for the proportion of insurers in this category would be 17.45 %.

| Year | N firms | Proportion of insurers (%) | | | | | | | | | | | |
|------|---------|----------------------------|-------|-----------|-------|-------------------------|------|-----------|-------|---------------------|-------|-----------|-------|
| | | <i>CONSISTENT_BETTER</i> | | | | <i>CONSISTENT_WORSE</i> | | | | <i>INCONSISTENT</i> | | | |
| | | Actual | | Simulated | | Actual | | Simulated | | Actual | | Simulated | |
| Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | | |
| 1993 | 907 | 34.51 | 12.90 | 17.45 | 23.59 | 22.93 | 5.18 | 8.48 | 11.91 | 42.56 | 68.69 | 74.07 | 79.27 |
| 1994 | 944 | 36.23 | 13.03 | 17.26 | 22.03 | 21.61 | 5.30 | 8.61 | 12.29 | 42.16 | 68.33 | 74.12 | 79.13 |
| 1995 | 921 | 32.14 | 10.75 | 15.30 | 20.74 | 22.80 | 6.62 | 10.03 | 13.79 | 45.06 | 68.73 | 74.67 | 79.91 |
| 1996 | 948 | 30.70 | 10.97 | 15.52 | 20.25 | 21.94 | 6.54 | 9.88 | 13.71 | 47.36 | 68.57 | 74.60 | 79.96 |
| 1997 | 955 | 32.77 | 11.73 | 15.42 | 20.00 | 24.29 | 6.39 | 9.96 | 13.93 | 42.93 | 69.21 | 74.62 | 80.10 |
| 1998 | 877 | 33.64 | 10.49 | 15.08 | 20.52 | 25.54 | 6.50 | 10.21 | 14.03 | 40.82 | 69.21 | 74.72 | 80.50 |
| 1999 | 849 | 32.98 | 10.72 | 15.29 | 20.38 | 21.67 | 6.12 | 10.04 | 14.02 | 45.35 | 68.67 | 74.67 | 80.68 |
| 2000 | 804 | 32.21 | 10.45 | 15.45 | 21.02 | 22.51 | 4.60 | 9.88 | 14.18 | 45.27 | 68.03 | 74.66 | 80.47 |
| 2001 | 832 | 35.70 | 11.90 | 17.04 | 21.75 | 22.12 | 5.53 | 8.81 | 12.98 | 42.19 | 68.99 | 74.15 | 80.05 |
| 2002 | 872 | 32.68 | 12.96 | 17.60 | 22.71 | 19.72 | 5.39 | 8.49 | 12.16 | 47.59 | 68.69 | 73.91 | 78.90 |
| 2003 | 977 | 30.09 | 13.31 | 17.54 | 22.72 | 17.40 | 5.02 | 8.52 | 12.59 | 52.51 | 68.58 | 73.94 | 80.76 |
| 2004 | 972 | 33.23 | 13.68 | 18.45 | 23.05 | 19.65 | 4.94 | 7.94 | 11.32 | 47.12 | 68.62 | 73.61 | 79.73 |
| 2005 | 986 | 38.13 | 15.11 | 19.62 | 24.34 | 18.97 | 4.46 | 7.34 | 10.65 | 42.90 | 67.65 | 73.05 | 77.59 |
| 2006 | 994 | 35.81 | 13.98 | 18.70 | 24.04 | 20.22 | 4.73 | 7.77 | 11.07 | 43.96 | 67.91 | 73.54 | 79.18 |
| 2007 | 997 | 32.70 | 12.54 | 16.64 | 21.06 | 20.16 | 5.82 | 9.04 | 12.64 | 47.14 | 69.41 | 74.32 | 79.24 |
| 2008 | 969 | 35.09 | 12.38 | 16.83 | 21.36 | 21.78 | 5.78 | 8.87 | 12.80 | 43.14 | 68.73 | 74.29 | 79.98 |
| 2009 | 951 | 35.96 | 12.72 | 17.32 | 23.03 | 23.66 | 5.47 | 8.59 | 12.20 | 40.38 | 68.45 | 74.08 | 79.92 |

Table 4 – Persistence of differences in insurer underwriting performance over time (after accounting for the business mix)

Insurers are categorized into *CONSISTENT_BETTER* and *CONSISTENT_WORSE* based on their underwriting performance in 2007-2009 (Panel A) or 2001-2003 (Panel B). The table shows each group's mean and median abnormal realized underwriting returns (*AUWRET*), in percent. The table also shows the percentage of insurers that have positive *AUWRET* in a given year. Differences in the mean (median) *AUWRET* between the two groups are determined by a *t*-test (Wilcoxon rank sum test). Differences in the percentage of insurers that have positive *AUWRET* in each year are determined by a chi-square test.

Panel A: Classification Based on 2007 to 2009

| Year | (a) <i>CONSISTENT_BETTER</i> | | | (b) <i>CONSISTENT_WORSE</i> | | | Diff.: (a) - (b) | | | | |
|------|------------------------------|---------------|--------|-----------------------------|---------------|--------|------------------|--------|-----------|-----------|------------|
| | N | <i>AUWRET</i> | | N | <i>AUWRET</i> | | Mean | Median | % | | |
| | | Mean | Median | | % | Mean | | | | Median | % |
| 1991 | 172 | 2.50 | 2.60 | 66.86 | 141 | -0.77 | 0.25 | 50.35 | 3.27 ** | 2.35 *** | 16.51 *** |
| 1992 | 188 | 2.82 | 2.88 | 67.55 | 146 | 2.87 | 4.34 | 67.12 | -0.05 | -1.46 | 0.43 |
| 1993 | 192 | 2.07 | 2.10 | 60.42 | 149 | 0.52 | 0.96 | 53.02 | 1.55 | 1.14 * | 7.40 |
| 1994 | 210 | 1.35 | 1.68 | 57.14 | 157 | 0.97 | 3.10 | 59.87 | 0.38 | -1.42 | -2.73 |
| 1995 | 224 | 3.74 | 3.80 | 65.18 | 164 | 0.25 | 0.59 | 54.27 | 3.49 *** | 3.20 *** | 10.91 ** |
| 1996 | 223 | 4.40 | 3.52 | 66.37 | 167 | -0.08 | -0.10 | 49.70 | 4.48 *** | 3.62 *** | 16.67 *** |
| 1997 | 223 | 2.52 | 1.47 | 59.64 | 158 | 0.63 | 0.51 | 51.90 | 1.89 | 0.96 | 7.74 |
| 1998 | 236 | 2.34 | 1.48 | 54.66 | 164 | 0.09 | -0.67 | 46.34 | 2.25 | 2.15 ** | 8.32 |
| 1999 | 250 | 2.31 | 1.33 | 61.20 | 177 | -0.42 | 0.77 | 53.11 | 2.73 * | 0.56 * | 8.09 |
| 2000 | 243 | 3.52 | 3.52 | 67.90 | 164 | -0.54 | 0.02 | 50.00 | 4.06 *** | 3.50 *** | 17.90 *** |
| 2001 | 268 | 3.14 | 2.10 | 59.33 | 189 | -0.51 | 0.63 | 52.91 | 3.66 *** | 1.47 *** | 6.42 |
| 2002 | 274 | 3.98 | 4.82 | 68.25 | 196 | -1.42 | -0.72 | 44.90 | 5.40 *** | 5.54 *** | 23.35 *** |
| 2003 | 276 | 3.99 | 5.05 | 71.74 | 210 | -1.49 | -0.18 | 49.52 | 5.47 *** | 5.23 *** | 22.22 *** |
| 2004 | 279 | 4.09 | 6.00 | 78.14 | 210 | -2.34 | -0.55 | 44.76 | 6.43 *** | 6.55 *** | 33.37 *** |
| 2005 | 288 | 5.01 | 5.34 | 76.04 | 220 | -3.17 | -1.03 | 45.91 | 8.18 *** | 6.37 *** | 30.13 *** |
| 2006 | 314 | 6.09 | 6.77 | 85.03 | 224 | -5.95 | -4.35 | 24.55 | 12.04 *** | 11.12 *** | 60.48 *** |
| 2007 | 321 | 9.61 | 8.84 | 100.00 | 236 | -11.45 | -7.54 | 0.00 | 21.06 *** | 16.38 *** | 100.00 *** |
| 2008 | 321 | 10.88 | 9.59 | 100.00 | 236 | -12.71 | -9.94 | 0.00 | 23.59 *** | 19.52 *** | 100.00 *** |
| 2009 | 321 | 12.09 | 10.76 | 100.00 | 236 | -13.29 | -8.96 | 0.00 | 25.38 *** | 19.72 *** | 100.00 *** |

Panel B: Classification Based on 2001 to 2003

| Year | (a) CONSISTENT_BETTER | | | (b) CONSISTENT_WORSE | | | Diff.: (a) - (b) | | |
|------|-----------------------|-------|--------|----------------------|--------|--------|------------------|-----------|------------|
| | N | Mean | Median | N | Mean | Median | Mean | Median | % |
| 1991 | 152 | 3.70 | 3.78 | 101 | -2.18 | -0.02 | 5.88 *** | 3.80 *** | 20.23 *** |
| 1992 | 164 | 5.23 | 4.90 | 106 | -3.79 | -0.84 | 9.02 *** | 5.74 *** | 25.94 *** |
| 1993 | 170 | 4.84 | 4.33 | 114 | -1.28 | -1.37 | 6.12 *** | 5.70 *** | 27.02 *** |
| 1994 | 189 | 4.34 | 6.04 | 124 | -2.47 | -0.41 | 6.81 *** | 6.45 *** | 22.79 *** |
| 1995 | 207 | 3.70 | 4.11 | 132 | -2.47 | -1.36 | 6.17 *** | 5.46 *** | 20.73 *** |
| 1996 | 210 | 4.86 | 3.93 | 135 | -1.62 | -2.22 | 6.48 *** | 6.15 *** | 25.93 *** |
| 1997 | 210 | 4.22 | 4.50 | 130 | -3.27 | -1.55 | 7.49 *** | 6.04 *** | 21.87 *** |
| 1998 | 220 | 4.89 | 4.80 | 132 | -5.77 | -5.59 | 10.66 *** | 10.38 *** | 37.73 *** |
| 1999 | 238 | 6.42 | 4.94 | 139 | -5.31 | -5.62 | 11.73 *** | 10.56 *** | 41.45 *** |
| 2000 | 233 | 7.44 | 7.66 | 140 | -8.26 | -4.51 | 15.70 *** | 12.17 *** | 46.40 *** |
| 2001 | 262 | 12.58 | 10.03 | 164 | -14.32 | -8.33 | 26.90 *** | 18.36 *** | 100.00 *** |
| 2002 | 262 | 11.66 | 9.56 | 164 | -14.23 | -8.73 | 25.89 *** | 18.29 *** | 100.00 *** |
| 2003 | 262 | 10.46 | 8.34 | 164 | -12.35 | -8.29 | 22.80 *** | 16.62 *** | 100.00 *** |
| 2004 | 243 | 6.28 | 6.91 | 152 | -7.75 | -3.81 | 14.03 *** | 10.72 *** | 48.91 *** |
| 2005 | 244 | 4.11 | 4.89 | 151 | -7.18 | -3.74 | 11.29 *** | 8.63 *** | 37.47 *** |
| 2006 | 240 | 3.09 | 3.11 | 146 | -5.93 | -4.26 | 9.01 *** | 7.37 *** | 36.62 *** |
| 2007 | 235 | 1.09 | 2.56 | 134 | -3.74 | -2.41 | 4.83 *** | 4.97 *** | 24.50 *** |
| 2008 | 227 | 2.15 | 3.91 | 127 | -3.15 | -1.80 | 5.30 *** | 5.71 *** | 22.30 *** |
| 2009 | 218 | 3.43 | 5.65 | 122 | -3.07 | -3.36 | 6.50 *** | 9.00 *** | 29.79 *** |

Table 5 - Consistency of underwriting performance across lines.

This table shows what percentage of *CONSISTENT_BETTER*, *CONSISTENT_WORSE* and *INCONSISTENT* insurers have superior underwriting performance in less than one quarter, one quarter to one half, one half to three quarters and more than three quarters of lines they write. Superior line-level underwriting performance is defined as having positive line-level abnormal realized underwriting return (*AUWRET_{lit}*). Insurer-level classification is done based on their underwriting performance in years $t-3$ through $t-1$, and line-level underwriting performance is in year t .

| | Insurer underwriting performance | | | p-values from a z-test for difference in proportions | | |
|---|----------------------------------|--------------------------------|----------------------------|--|-----------|-----------|
| | (a) <i>CONSISTENT_BETTER</i> | (b) <i>CONSISTENT_WORSE</i> | (c) <i>INCONSISTENT</i> | (a) - (b) | (a) - (c) | (b) - (c) |
| N insurers | 1,639 | 924 | 2,091 | | | |
| % insurers whose proportion of lines with superior underwriting performance is between: | | | | | | |
| 0 to 25 % | 4.33 | 21.75 | 10.09 | 0.0000 | 0.0000 | 0.0000 |
| 25 to 50 % | 19.52 | 38.42 | 29.41 | 0.0000 | 0.0000 | 0.0000 |
| 50 to 75 % | 43.44 | 30.63 | 41.75 | 0.0000 | 0.3000 | 0.0000 |
| 75 to 100 % | 32.70 | 9.20 | 18.75 | 0.0000 | 0.0000 | 0.0000 |
| Total % insurers | 100.00 | 100.00 | 100.00 | | | |

Table 6 - Insurers' investment portfolio composition and regulatory risk-based capital charge

This table shows the sample average percentages of invested assets allocated to different asset classes (as defined by NAIC) as well as the risk-based capital charges assigned to each class. Investments in stocks and bonds of affiliates are excluded.

| Asset Class | Percent of invested assets (industry average) | Risk-based capital charge |
|--|--|--------------------------------------|
| Bonds (incl. hybrid securities) | | |
| - NAIC risk class 1 ("Highest Quality") | 21.79% | 0.00% |
| - U.S. government bonds | 47.20% | 0.30% |
| - other bonds | 4.35% | 1.00% |
| - NAIC risk class 2 ("High Quality") | 0.48% | 2.00% |
| - NAIC risk class 3 ("Medium Quality") | 0.22% | 4.50% |
| - NAIC risk class 4 ("Low Quality") | 0.07% | 10.00% |
| - NAIC risk class 5 ("Lower Quality") | 0.05% | 30.00% |
| - NAIC risk class 6 ("In or Near Default") | 12.36% | 15.00% |
| Common stocks | 10.77% | 0.30% |
| Cash and short-term investments | 2.73% | 0.14% to 30% |
| Other assets | 100.00% | - |
| TOTAL | | |

Table 7 - Descriptive statistics for insurers' investment risk and returns

$INVRSK_{it}$ is the percentage of assets invested in common stocks and risky bonds (bonds in NAIC risk classes 4 through 6). $WINVRSK_{it}$ is the portfolio-weighted regulatory capital risk charge. $INVRET_{it}$ is the investment return, and RA_INVRET_{it} is the risk- and duration-adjusted investment return obtained by insurer i in year t .

| | $INVRSK_{it}$ (%) | $WINVRSK_{it}$ (%) | $INVRET_{it}$ (%) | RA_INVRET_{it} (%) |
|---------------------------|-------------------|--------------------|-------------------|-----------------------|
| Mean | 12.59 | 2.10 | 5.58 | 0.00 |
| Std. Dev. | 15.20 | 2.24 | 3.38 | 2.36 |
| Min | 0.00 | 0.03 | -18.93 | -20.37 |
| Percentile: | | | | |
| 1 st | 0.00 | 0.05 | -4.77 | -6.90 |
| 5 th | 0.00 | 0.16 | 1.00 | -3.39 |
| 10 th | 0.00 | 0.22 | 2.47 | -2.21 |
| 25 th | 0.18 | 0.34 | 4.02 | -0.97 |
| 50 th (median) | 7.27 | 1.32 | 5.45 | -0.02 |
| 75 th | 19.12 | 3.06 | 7.11 | 0.88 |
| 90 th | 33.47 | 5.17 | 9.12 | 2.21 |
| 95 th | 45.71 | 6.97 | 10.79 | 3.72 |
| 99 th | 65.03 | 9.93 | 16.00 | 7.53 |
| Max | 78.03 | 11.68 | 25.37 | 20.03 |

Table 8 – Differences in insurer investment performance and risk taking, by underwriting performance

Insurers are categorized into *CONSISTENT_BETTER* and *CONSISTENT_WORSE* based on their underwriting performance compared to companies with a similar business mix in 2007-2009 (Panel A) or 2001-2003 (Panel B). The table shows each group's mean values of *INVRISK_{it}* and *RA_INVRET_{it}*, where *INVRISK_{it}* is the percentage of assets invested in common stocks and risky bonds (bonds in NAIC risk classes 4 through 6) and *RA_INVRET_{it}* is the risk- and duration-adjusted investment return obtained by insurer *i* in year *t*. Both *INVRISK_{it}* and *RA_INVRET_{it}* are in percent.

Panel A: Classification Based on 2007 to 2009

| Year | (a) <i>CONSISTENT_BETTER</i> | | (b) <i>CONSISTENT_WORSE</i> | | Diff.: (a) - (b) | |
|------|------------------------------|--------------------------|-----------------------------|--------------------------|------------------|------------------|
| | N | <i>INVRISK RA_INVRET</i> | N | <i>INVRISK RA_INVRET</i> | <i>INVRISK</i> | <i>RA_INVRET</i> |
| 1991 | 172 | 12.44 -0.19 | 141 | 14.28 -0.21 | -1.84 | 0.01 |
| 1992 | 188 | 11.84 -0.11 | 146 | 14.11 -0.07 | -2.27 | -0.04 |
| 1993 | 192 | 11.71 -0.14 | 149 | 14.04 -0.29 | -2.34 | 0.15 |
| 1994 | 210 | 10.38 -0.14 | 157 | 12.94 -0.28 | -2.56 * | 0.14 |
| 1995 | 224 | 10.93 -0.26 | 164 | 14.48 0.02 | -3.56 ** | -0.28 |
| 1996 | 223 | 11.12 -0.25 | 167 | 15.85 0.13 | -4.73 *** | -0.38 * |
| 1997 | 223 | 12.49 0.27 | 158 | 17.19 -0.07 | -4.70 *** | 0.35 |
| 1998 | 236 | 13.27 0.11 | 164 | 18.09 -0.26 | -4.82 *** | 0.37 |
| 1999 | 250 | 13.85 -0.24 | 177 | 18.35 0.32 | -4.51 *** | -0.56 * |
| 2000 | 243 | 12.72 0.10 | 164 | 17.88 0.30 | -5.16 *** | -0.19 |
| 2001 | 268 | 11.94 0.19 | 189 | 16.95 0.09 | -5.02 *** | 0.10 |
| 2002 | 274 | 10.92 0.09 | 196 | 14.44 -0.30 | -3.52 *** | 0.39 |
| 2003 | 276 | 11.67 0.18 | 210 | 15.26 -0.19 | -3.59 ** | 0.36 * |
| 2004 | 279 | 11.56 0.02 | 210 | 14.95 -0.06 | -3.38 ** | 0.08 |
| 2005 | 288 | 11.63 0.13 | 220 | 14.94 -0.19 | -3.31 ** | 0.32 ** |
| 2006 | 314 | 11.73 0.04 | 224 | 14.68 -0.16 | -2.95 ** | 0.20 * |
| 2007 | 321 | 11.91 -0.08 | 236 | 14.69 -0.02 | -2.78 ** | -0.07 |
| 2008 | 321 | 9.92 0.18 | 236 | 13.43 -0.28 | -3.51 *** | 0.47 |
| 2009 | 321 | 10.68 0.08 | 236 | 14.75 0.10 | -4.07 *** | -0.02 |

Panel B: Classification Based on 2001 to 2003

| Year | (a) CONSISTENT_BETTER | | (b) CONSISTENT_WORSE | | Diff.: (a) - (b) | |
|------|-----------------------|-------------------|----------------------|-------------------|------------------|-----------|
| | N | INVRISK RA_INVRET | N | INVRISK RA_INVRET | INVRISK | RA_INVRET |
| 1991 | 152 | 11.66 -0.34 | 101 | 12.67 0.05 | -1.02 | -0.40 |
| 1992 | 164 | 11.50 -0.01 | 106 | 11.41 -0.19 | 0.09 | 0.18 |
| 1993 | 170 | 11.17 -0.33 | 114 | 11.89 -0.08 | -0.72 | -0.25 |
| 1994 | 189 | 9.73 -0.12 | 124 | 11.77 0.07 | -2.04 | -0.19 |
| 1995 | 207 | 10.18 -0.20 | 132 | 11.59 0.26 | -1.41 | -0.46 ** |
| 1996 | 210 | 10.78 -0.08 | 135 | 13.10 0.08 | -2.33 | -0.16 |
| 1997 | 210 | 11.48 0.00 | 130 | 14.50 -0.25 | -3.02 * | 0.25 |
| 1998 | 220 | 11.99 0.02 | 132 | 16.47 -0.10 | -4.49 ** | 0.12 |
| 1999 | 238 | 12.46 -0.18 | 139 | 16.67 0.34 | -4.21 ** | -0.52 |
| 2000 | 233 | 11.79 0.18 | 140 | 15.00 -0.27 | -3.22 * | 0.45 |
| 2001 | 262 | 11.51 -0.05 | 164 | 14.78 0.29 | -3.27 ** | -0.34 |
| 2002 | 262 | 10.53 0.03 | 164 | 12.85 0.19 | -2.32 * | -0.16 |
| 2003 | 262 | 11.81 0.09 | 164 | 13.67 -0.03 | -1.86 | 0.12 |
| 2004 | 243 | 12.30 0.05 | 152 | 12.87 0.21 | -0.57 | -0.16 |
| 2005 | 244 | 12.33 -0.09 | 151 | 14.06 0.20 | -1.72 | -0.29 * |
| 2006 | 240 | 13.21 -0.05 | 146 | 14.47 0.07 | -1.26 | -0.11 |
| 2007 | 235 | 13.17 -0.19 | 134 | 12.54 0.07 | 0.62 | -0.26 * |
| 2008 | 227 | 11.31 -0.47 | 127 | 12.32 -0.21 | -1.00 | -0.26 |
| 2009 | 218 | 12.44 0.09 | 122 | 13.45 0.27 | -1.01 | -0.18 |

Table 9 - Descriptive statistics for insurer characteristics.

Affiliated equals 1 for insurers affiliated with a group and 0 for unaffiliated insurers. Independent Agent equals 1 for insurers that use independent agents as the distribution channel and 0 otherwise. Size is defined as natural log of total assets (in \$1000). Product and geographical concentrations are Herfindahl indices (concentration of 1 means that the insurer operates only in one line of business or one state, respectively). AM Best rating ranges from 3 (C- "Weak") to 14 (A++ "Superior") - more details in Table 10. Reinsurance ceded is the proportion of direct premiums written ceded to reinsurers. Growth is defined as the natural log of the ratio of net premiums written in the current year to net premiums written last year; it is winsorized at 1 % on both sides, by year. Leverage is the ratio of net premiums written to policyholder surplus.

| Variable | Mean | Std. Dev. | Min | 25th perc. | Median | 75th perc. | Max |
|----------------------|-------|-----------|-------|------------|--------|------------|-------|
| Organizational form: | | | | | | | |
| Stock | 0.75 | - | 0 | - | - | - | 1 |
| Mutual | 0.25 | - | 0 | - | - | - | 1 |
| Affiliated | 0.75 | - | 0 | - | - | - | 1 |
| Independent Agent | 0.79 | - | 0 | - | - | - | 1 |
| Size | 18.56 | 1.72 | 14.40 | 17.30 | 18.43 | 19.66 | 25.38 |
| Concentration: | | | | | | | |
| Product | 0.46 | 0.32 | 0.02 | 0.19 | 0.37 | 0.73 | 1.00 |
| Geographical | 0.52 | 0.38 | 0.03 | 0.14 | 0.45 | 1.00 | 1.00 |
| AM Best rating | 11.43 | 1.65 | 3 | 11 | 12 | 13 | 14 |
| Reinsurance ceded | 0.38 | 0.27 | 0.00 | 0.14 | 0.33 | 0.59 | 0.96 |
| Growth | 0.07 | 0.25 | -0.82 | -0.04 | 0.05 | 0.14 | 1.57 |
| Leverage | 1.18 | 0.73 | 0.00 | 0.63 | 1.07 | 1.61 | 5.84 |

Table 10 - Conversion of AM Best ratings to numerical values.

AM Best rating agency defines its Financial Strength Rating as "an independent opinion of an insurer's financial strength and ability to meet its ongoing insurance policy and contract obligations."

| Best's Rating | Numerical value | Description |
|----------------------|------------------------|--|
| A++ | 14 | Superior |
| A+ | 13 | |
| A | 12 | Excellent |
| A- | 11 | |
| B++ | 10 | Good |
| B+ | 9 | |
| B | 8 | Fair |
| B- | 7 | |
| C++ | 6 | Marginal |
| C+ | 5 | |
| C | 4 | Weak |
| C- | 3 | |
| D | 2 | Poor |
| E/F | 1 | Under regulatory control or in liquidation |

Table 11 - Underwriting discipline and investment strategy: regression analyses

$INVRISK_{it}$ is the percentage of assets invested by insurer i in year t in common stocks and risky bonds (bonds in NAIC risk classes 4 through 6), in %. $WINVRISK_{it}$ is the portfolio-weighted regulatory capital risk charge, in %. RA_INVRET_{it} is the risk- and duration-adjusted investment return obtained by insurer i in year t , in %. The measure of underwriting discipline $UWD_CAT_{i,t-5,t-1}$ has four categories reflecting both the strength and the consistency of an insurer's underwriting performance: *STRONG* (chosen as base), *MEDIUM*, *WEAK* and *INCONSISTENT*. See the note to Table 9 for the definitions of firm characteristics. Standard errors ("SE") are clustered by firm. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.1 level.

| <i>Dep. var.:</i> | (1) | | (2) | | (3) | |
|--|--------------------------------------|----------|---------------------------------------|----------|--|----------|
| | <i>INVRISK</i> _{<i>i,t</i>} | | <i>WINVRISK</i> _{<i>i,t</i>} | | <i>RA_INVRET</i> _{<i>i,t</i>} | |
| | Coef. | SE | Coef. | SE | Coef. | SE |
| <i>UWD_CAT</i> _{<i>i,t-5,t-1</i>} | | | | | | |
| <i>WEAK</i> | 0.94 | 0.41 ** | 0.14 | 0.06 ** | -0.01 | 0.10 |
| <i>MEDIUM</i> | 0.74 | 0.32 ** | 0.11 | 0.05 ** | -0.15 | 0.08 * |
| <i>INCONSISTENT</i> | 0.23 | 0.43 | 0.03 | 0.06 | -0.04 | 0.09 |
| Mutual | 2.34 | 1.56 | 0.33 | 0.23 | -0.08 | 0.28 |
| Affiliated | 4.02 | 1.21 *** | 0.59 | 0.18 *** | -0.02 | 0.23 |
| Independent Agent | 2.03 | 0.74 *** | 0.28 | 0.11 *** | 0.07 | 0.13 |
| Size | 2.19 | 1.34 | 0.32 | 0.20 | 0.15 | 0.13 |
| Product concentration | -3.32 | 1.96 * | -0.48 | 0.29 | 0.37 | 0.33 |
| Geogr. concentration | 0.45 | 1.97 | 0.01 | 0.30 | -0.40 | 0.34 |
| AM Best rating | -0.05 | 0.25 | -0.01 | 0.04 | -0.06 | 0.05 |
| Reinsurance ceded | -1.71 | 1.52 | -0.29 | 0.23 | -0.36 | 0.29 |
| Growth | 1.25 | 0.50 ** | 0.20 | 0.08 *** | -0.26 | 0.18 |
| Growth^2 | -2.05 | 0.79 ** | -0.30 | 0.12 ** | 0.09 | 0.26 |
| Leverage | -9.11 | 1.43 *** | -1.38 | 0.21 *** | -1.54 | 0.23 *** |
| Leverage^2 | 1.89 | 0.34 *** | 0.28 | 0.05 *** | 0.28 | 0.06 *** |
| Firm FE and Year FE | Yes | | Yes | | Yes | |
| N | | 10,078 | | 10,078 | | 10,078 |
| R sq. | | 0.086 | | 0.087 | | 0.015 |

Table A.1 – Actual vs. simulated proportions of insurers with consistent and inconsistent underwriting performance (after accounting for product lines, states and insurer characteristics, for the subsample of firms that remain in the industry throughout 1991-2014)

This simulation is performed for the subsample of insurers that remain in the industry throughout 1991-2014. Insurers classified in year t as *CONSISTENT_BETTER* (*CONSISTENT_WORSE*) have only positive (negative) abnormal realized underwriting returns over the three-year period from $t - 2$ through t , while *INCONSISTENT* insurers have both. The abnormal realized underwriting return used in this simulation accounts for insurer business mix (both product lines and states in which an insurer operates). The columns labeled “Actual” show the actual proportions of U.S. P/L insurers falling into each category. The columns labeled “Simulated” report the results of the simulation designed to estimate what proportion of insurers would fall into each category if insurers did not differ with respect to underwriting discipline. This simulation separates insurers into buckets depending on their size quartile, organizational form and distribution system; the probability of a positive abnormal return is allowed to vary by bucket (and by year). The simulation generates 10,000 realizations for each annual proportion; columns “Mean”, “Min” and “Max” report the average as well as the smallest and the largest of these realizations for each category each year. For example, 28.25% of insurers are classified as *CONSISTENT_BETTER* in 1993, meaning that they have positive abnormal underwriting returns in each year from 1991 to 1993. The simulation predicts that only 11.04 to 20.11% of insurers could fall into this category in 1993 if there were no differences in underwriting discipline.

| Year | N firms | Proportion of insurers (%) | | | | | | | | | | | | | |
|------|---------|----------------------------|-------|-----------|-------|--------|------|-------------------------|-------|--------|-------|-----------|-------|---------------------|-----|
| | | <i>CONSISTENT_BETTER</i> | | | | | | <i>CONSISTENT_WORSE</i> | | | | | | <i>INCONSISTENT</i> | |
| | | Actual | | Simulated | | Actual | | Simulated | | Actual | | Simulated | | Mean | Max |
| Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Mean | Max | | |
| 1993 | 761 | 28.25 | 11.04 | 15.64 | 20.11 | 22.21 | 7.10 | 11.05 | 15.11 | 49.54 | 67.54 | 73.31 | 79.37 | | |
| 1994 | 790 | 30.63 | 11.27 | 16.30 | 21.14 | 22.53 | 6.46 | 10.13 | 14.43 | 46.84 | 67.97 | 73.57 | 79.37 | | |
| 1995 | 791 | 27.31 | 10.75 | 15.21 | 19.85 | 22.25 | 7.08 | 10.68 | 14.92 | 50.44 | 68.14 | 74.12 | 80.28 | | |
| 1996 | 806 | 23.45 | 10.55 | 14.64 | 19.23 | 22.21 | 6.95 | 11.31 | 15.14 | 54.34 | 68.36 | 74.05 | 79.78 | | |
| 1997 | 778 | 23.52 | 9.64 | 14.16 | 18.64 | 21.98 | 7.46 | 11.28 | 16.07 | 54.50 | 68.12 | 74.56 | 80.59 | | |
| 1998 | 730 | 26.16 | 10.55 | 14.94 | 19.86 | 22.60 | 6.71 | 11.29 | 16.03 | 51.23 | 66.85 | 73.77 | 79.59 | | |
| 1999 | 707 | 29.99 | 11.60 | 16.35 | 21.92 | 23.90 | 7.07 | 10.96 | 15.28 | 46.11 | 65.91 | 72.70 | 79.07 | | |
| 2000 | 658 | 30.85 | 12.16 | 17.49 | 22.80 | 21.73 | 7.29 | 11.31 | 16.26 | 47.42 | 64.74 | 71.20 | 77.51 | | |
| 2001 | 674 | 33.23 | 14.99 | 19.76 | 25.22 | 19.29 | 5.79 | 9.65 | 14.39 | 47.48 | 64.24 | 70.60 | 76.85 | | |
| 2002 | 688 | 29.36 | 13.23 | 18.91 | 23.98 | 16.86 | 4.07 | 7.89 | 12.21 | 53.78 | 67.15 | 73.19 | 79.36 | | |
| 2003 | 765 | 24.58 | 11.24 | 16.97 | 22.22 | 15.56 | 5.23 | 8.40 | 12.29 | 59.87 | 69.02 | 74.62 | 80.52 | | |
| 2004 | 751 | 25.17 | 11.05 | 16.03 | 20.91 | 19.04 | 6.52 | 10.39 | 14.38 | 55.79 | 67.38 | 73.58 | 79.76 | | |
| 2005 | 742 | 28.71 | 10.65 | 15.36 | 21.43 | 20.75 | 6.20 | 10.52 | 14.82 | 50.54 | 67.79 | 74.12 | 80.86 | | |
| 2006 | 737 | 27.82 | 10.99 | 15.73 | 20.90 | 22.25 | 6.24 | 10.61 | 15.74 | 49.93 | 67.98 | 73.66 | 79.38 | | |
| 2007 | 729 | 27.98 | 11.25 | 16.12 | 21.26 | 21.26 | 6.86 | 10.93 | 15.91 | 50.75 | 66.94 | 72.95 | 79.56 | | |
| 2008 | 685 | 28.76 | 9.64 | 14.50 | 19.71 | 23.94 | 7.59 | 11.95 | 17.52 | 47.30 | 66.28 | 73.56 | 79.85 | | |
| 2009 | 662 | 28.25 | 10.27 | 15.02 | 20.09 | 22.36 | 6.50 | 11.00 | 16.62 | 49.40 | 67.67 | 73.98 | 81.72 | | |

Table A.2 – Persistence of differences in insurer underwriting performance over time (after accounting for product lines and states, for the subsample of firms that remain in the industry throughout 1991-2014)

This analysis is performed on the subsample of insurers that remain in the industry throughout 1991-2014. Insurers are categorized into *CONSISTENT_BETTER* and *CONSISTENT_WORSE* based on their underwriting performance in 2007-2009 (Panel A) or 2001-2003 (Panel B). The table shows each group's mean and median abnormal realized underwriting returns (*AUWRET*), in percent, which account for the proportions of premiums written by an insurer in each product line and state. The table also shows the percentage of insurers that have positive *AUWRET* in a given year. Differences in the mean (median) *AUWRET* between the two groups are determined by a *t*-test (Wilcoxon rank sum test). Differences in the percentage of insurers that have positive *AUWRET* in each year are determined by a chi-square test.

Panel A: Classification Based on 2007 to 2009

| Year | (a) <i>CONSISTENT_BETTER</i> | | | (b) <i>CONSISTENT_WORSE</i> | | | Diff.: (a) - (b) | | |
|------|------------------------------|-------|--------|-----------------------------|--------|--------|------------------|-----------|------------|
| | N | Mean | Median | N | Mean | Median | Mean | Median | % |
| 1991 | 139 | 1.46 | 1.27 | 115 | -1.64 | -1.77 | 3.10 ** | 3.04 * | 9.31 |
| 1992 | 149 | 0.65 | -0.06 | 123 | 2.92 | 3.23 | -2.28 * | -3.30 * | -15.76 ** |
| 1993 | 153 | -0.66 | -0.28 | 128 | 0.21 | 0.78 | -0.87 | -1.06 | -4.76 |
| 1994 | 166 | -0.64 | 0.56 | 130 | 0.14 | 2.31 | -0.78 | -1.75 | -5.89 |
| 1995 | 168 | 1.10 | 1.49 | 135 | 0.28 | -0.36 | 0.82 | 1.85 | 9.89 |
| 1996 | 168 | 1.24 | 0.37 | 136 | -0.10 | 0.18 | 1.34 | 0.19 | 2.98 |
| 1997 | 168 | 0.28 | 0.56 | 127 | 1.03 | 1.29 | -0.75 | -0.73 | -6.08 |
| 1998 | 167 | 0.39 | 0.31 | 134 | 2.67 | 2.18 | -2.28 | -1.87 * | -9.25 |
| 1999 | 170 | -0.76 | -0.62 | 138 | 1.44 | 3.55 | -2.20 | -4.17 ** | -12.05 ** |
| 2000 | 159 | 0.33 | 1.48 | 120 | 1.92 | 1.98 | -1.59 | -0.50 | -4.23 |
| 2001 | 173 | 1.20 | 2.77 | 134 | 2.05 | 2.98 | -0.85 | -0.21 | -5.72 |
| 2002 | 170 | 2.92 | 3.82 | 136 | -0.64 | 0.55 | 3.56 *** | 3.28 *** | 11.47 * |
| 2003 | 178 | 2.17 | 3.48 | 142 | 0.23 | 0.09 | 1.94 | 3.39 ** | 11.09 * |
| 2004 | 179 | 3.30 | 3.95 | 143 | -0.37 | -0.99 | 3.67 *** | 4.94 *** | 24.10 *** |
| 2005 | 182 | 3.47 | 4.23 | 144 | -1.87 | -0.67 | 5.34 *** | 4.90 *** | 24.90 *** |
| 2006 | 185 | 6.41 | 6.74 | 145 | -6.58 | -6.16 | 12.99 *** | 12.89 *** | 61.03 *** |
| 2007 | 187 | 9.90 | 8.17 | 148 | -11.00 | -8.17 | 20.90 *** | 16.33 *** | 100.00 *** |
| 2008 | 187 | 10.76 | 9.20 | 148 | -9.98 | -6.99 | 20.75 *** | 16.18 *** | 100.00 *** |
| 2009 | 187 | 10.33 | 8.83 | 148 | -12.34 | -8.18 | 22.67 *** | 17.01 *** | 100.00 *** |

Panel B: Classification Based on 2001 to 2003

| Year | (a) CONSISTENT_BETTER | | | | (b) CONSISTENT_WORSE | | | | Diff.: (a) - (b) | | | | |
|------|-----------------------|-------|--------|--------|----------------------|--------|--------|-------|------------------|-----------|------|--------|------------|
| | N | Mean | Median | % | N | Mean | Median | % | Mean | Median | Mean | Median | % |
| 1991 | 144 | 2.41 | 1.29 | 54.86 | 89 | -1.67 | -1.00 | 47.19 | 4.08 *** | 2.29 ** | | | 7.67 |
| 1992 | 158 | 1.98 | 1.81 | 60.76 | 98 | -1.76 | 1.57 | 54.08 | 3.74 ** | 0.24 | | | 6.68 |
| 1993 | 163 | 2.10 | 2.65 | 62.58 | 103 | 0.09 | 1.38 | 53.40 | 2.00 | 1.27 | | | 9.18 |
| 1994 | 171 | 2.96 | 3.48 | 60.82 | 110 | -0.26 | 1.51 | 58.18 | 3.22 * | 1.97 * | | | 2.64 |
| 1995 | 174 | 1.49 | 1.42 | 59.77 | 112 | -0.79 | -0.37 | 48.21 | 2.28 * | 1.79 * | | | 11.56 * |
| 1996 | 174 | 2.84 | 1.93 | 59.77 | 113 | 0.72 | 0.18 | 50.44 | 2.12 | 1.75 * | | | 9.33 |
| 1997 | 170 | 2.64 | 3.36 | 61.18 | 104 | -1.24 | 0.94 | 54.81 | 3.87 *** | 2.43 *** | | | 6.37 |
| 1998 | 173 | 2.85 | 2.46 | 61.85 | 107 | -3.60 | -3.51 | 39.25 | 6.45 *** | 5.97 *** | | | 22.60 *** |
| 1999 | 181 | 4.52 | 4.70 | 69.06 | 110 | -3.83 | -3.44 | 39.09 | 8.35 *** | 8.14 *** | | | 29.97 *** |
| 2000 | 171 | 4.71 | 4.91 | 73.10 | 104 | -6.01 | -5.09 | 33.65 | 10.72 *** | 10.00 *** | | | 39.45 *** |
| 2001 | 188 | 9.65 | 8.10 | 100.00 | 119 | -10.99 | -7.59 | 0.00 | 20.63 *** | 15.69 *** | | | 100.00 *** |
| 2002 | 188 | 10.76 | 9.80 | 100.00 | 119 | -13.23 | -9.22 | 0.00 | 23.98 *** | 19.02 *** | | | 100.00 *** |
| 2003 | 188 | 9.31 | 7.76 | 100.00 | 119 | -10.87 | -8.04 | 0.00 | 20.18 *** | 15.81 *** | | | 100.00 *** |
| 2004 | 177 | 4.70 | 5.54 | 70.06 | 111 | -4.51 | -3.98 | 33.33 | 9.20 *** | 9.52 *** | | | 36.72 *** |
| 2005 | 175 | 2.39 | 2.98 | 61.14 | 108 | -3.37 | -2.67 | 39.81 | 5.76 *** | 5.65 *** | | | 21.33 *** |
| 2006 | 174 | 0.87 | 0.52 | 55.17 | 104 | -2.60 | -3.61 | 38.46 | 3.46 ** | 4.13 *** | | | 16.71 ** |
| 2007 | 172 | -0.87 | 0.50 | 51.16 | 96 | -0.02 | -1.62 | 43.75 | -0.85 | 2.12 | | | 7.41 |
| 2008 | 167 | -0.45 | 1.09 | 52.10 | 91 | 0.99 | 0.00 | 49.45 | -1.45 | 1.10 | | | 2.65 |
| 2009 | 157 | 1.24 | 2.66 | 63.06 | 91 | 0.68 | 1.01 | 52.75 | 0.56 | 1.65 | | | 10.31 |

Table A.3 – Underwriting discipline and investment strategy: regression analyses (for the subsample of firms that remain in the industry throughout 1991–2014)

This analysis is performed on the subsample of insurers that remain in the industry throughout 1991–2014. $INVRISK_{it}$ is the percentage of assets invested by insurer i in year t in common stocks and risky bonds (bonds in NAIC risk classes 4 through 6), in %. $WINVRISK_{it}$ is the portfolio-weighted regulatory capital risk charge, in %. RA_INVRET_{it} is the risk- and duration-adjusted investment return obtained by insurer i in year t , in %. The measure of underwriting discipline $UWD_CAT_{i,t-5,t-1}$ has four categories reflecting both the strength and the consistency of an insurer's underwriting performance: *STRONG* (chosen as base), *MEDIUM*, *WEAK* and *INCONSISTENT*. See the note to Table 9 for the definitions of firm characteristics. Standard errors ("SE") are clustered by firm. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.1 level.

| <i>Dep. var.:</i> | (1) | | (2) | | (3) | |
|------------------------------------|-----------------------------|----------|------------------------------|----------|-------------------------------|----------|
| | <i>INVRISK_{it}</i> | | <i>WINVRISK_{it}</i> | | <i>RA_INVRET_{it}</i> | |
| | Coef. | SE | Coef. | SE | Coef. | SE |
| <i>UWD_CAT_{i,t-5,t-1}</i> | | | | | | |
| <i>WEAK</i> | 1.52 | 0.44 *** | 0.23 | 0.06 *** | 0.04 | 0.11 |
| <i>MEDIUM</i> | 1.07 | 0.33 *** | 0.15 | 0.05 *** | -0.11 | 0.09 |
| <i>INCONSISTENT</i> | 0.53 | 0.45 | 0.07 | 0.07 | -0.03 | 0.11 |
| Mutual | 2.42 | 1.61 | 0.34 | 0.24 | -0.05 | 0.29 |
| Affiliated | 4.10 | 1.23 *** | 0.61 | 0.18 *** | -0.04 | 0.24 |
| Independent Agent | 1.96 | 0.81 ** | 0.28 | 0.12 ** | 0.04 | 0.14 |
| Size | 2.16 | 1.43 | 0.32 | 0.21 | 0.17 | 0.13 |
| Product concentration | -2.20 | 1.93 | -0.30 | 0.28 | 0.45 | 0.36 |
| Geogr. concentration | 2.41 | 2.01 | 0.31 | 0.30 | -0.20 | 0.38 |
| AM Best rating | 0.03 | 0.27 | 0.00 | 0.04 | -0.06 | 0.05 |
| Reinsurance ceded | -1.36 | 1.67 | -0.24 | 0.25 | -0.19 | 0.33 |
| Growth | 1.33 | 0.51 ** | 0.21 | 0.08 *** | -0.27 | 0.19 |
| Growth ² | -2.57 | 0.94 *** | -0.37 | 0.14 *** | 0.29 | 0.34 |
| Leverage | -9.38 | 1.54 *** | -1.42 | 0.23 *** | -1.73 | 0.25 *** |
| Leverage ² | 1.97 | 0.38 *** | 0.30 | 0.06 *** | 0.33 | 0.06 *** |
| Firm FE and Year FE | Yes | | Yes | | Yes | |
| N | 8,635 | | 8,635 | | 8,635 | |
| R sq. | 0.088 | | 0.090 | | 0.017 | |

Table B – Comparison of UWRET_CONSISTENCY and AUWRET_CONSISTENCY

$UWRET_CONSISTENCY_{it}$ and $AUWRET_CONSISTENCY_{it}$ are determined using insurer underwriting performance over three-year periods. $UWRET_CONSISTENCY_{it}$ equals $CONSISTENT_PROFIT$ ($CONSISTENT_LOSS$) if insurer i has underwriting profits (losses) in each year from $t-2$ to t ; otherwise, it equals $INCONSISTENT$. $AUWRET_CONSISTENCY_{it}$ accounts for insurer business mix; it equals $CONSISTENT_BETTER$ ($CONSISTENT_WORSE$) if insurer i has positive (negative) abnormal realized underwriting return in each year from $t-2$ to t ; otherwise, it equals $INCONSISTENT$.

Panel A: Percentage of insurers in each UWRET_CONSISTENCY category that fall into each AUWRET_CONSISTENCY category

| | AUWRET_CONSISTENCY | | Total |
|---------------------------|-----------------------|----------------------|-------|
| | CONSISTENT_ BETTER | CONSISTENT_ WORSE | |
| <i>UWRET_CONSISTENCY:</i> | | | |
| <i>CONSISTENT_PROFIT</i> | 66.80 | 4.87 | 28.33 |
| <i>CONSISTENT_LOSS</i> | 2.53 | 71.92 | 25.56 |
| <i>INCONSISTENT</i> | 13.42 | 17.84 | 68.74 |

Panel B: Percentage of insurers in each AUWRET_CONSISTENCY category that fall into each UWRET_CONSISTENCY category

| | UWRET_CONSISTENCY | | Total |
|----------------------------|-----------------------|---------------------|-------|
| | CONSISTENT_ PROFIT | CONSISTENT_ LOSS | |
| <i>AUWRET_CONSISTENCY:</i> | | | |
| <i>CONSISTENT_BETTER</i> | 82.26 | 1.26 | 16.49 |
| <i>CONSISTENT_WORSE</i> | 9.42 | 56.17 | 34.41 |
| <i>INCONSISTENT</i> | 26.41 | 9.63 | 63.96 |

Table C.1 – Actual vs. simulated proportions of insurers with consistent and inconsistent underwriting performance (after accounting for differences in product-line distributions of underwriting returns)

Insurers classified in year t as *CONSISTENT_BETTER* or *CONSISTENT_WORSE* have respectively only positive or only negative abnormal realized underwriting returns over the three-year period from $t - 2$ through t , while *INCONSISTENT* insurers have both. The columns labeled “Actual” show the actual proportions of U.S. P/L insurers falling into each category. The columns labeled “Simulated” report the results of the simulation designed to estimate what proportion of insurers would fall into each category if insurers did not differ with respect to underwriting discipline. A simulated return for an insurer in a given year is calculated as a weighted average of firm-line-level returns, which are drawn randomly from the respective year’s distributions of firm-line-level underwriting returns. (The weights are the insurer’s proportions of premiums written in each line of business.) The simulation generates 10,000 realizations for each annual proportion; columns “Mean”, “Min” and “Max” report the average as well as the smallest and the largest of these realizations for each category each year. For example, 30.87% of insurers are classified as *CONSISTENT_BETTER* in 1993, meaning that they have positive abnormal underwriting returns in each year from 1991 to 1993. The simulation predicts that only 10.51 to 16.91% of insurers could fall into this category in 1993 if there were no differences in underwriting discipline; under this hypothesis, the best guess for the proportion of insurers in this category would be 14.04%.

| Year | N firms | Proportion of insurers (%) | | | | | | | | | | | |
|------|---------|----------------------------|-----------|-------|-------|-------------------------|-----------|-------|-------|---------------------|-----------|-------|-------|
| | | <i>CONSISTENT_BETTER</i> | | | | <i>CONSISTENT_WORSE</i> | | | | <i>INCONSISTENT</i> | | | |
| | | Actual | Simulated | | | Actual | Simulated | | | Actual | Simulated | | |
| | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max | |
| 1993 | 609 | 30.87 | 10.51 | 14.04 | 16.91 | 28.08 | 7.55 | 11.21 | 15.11 | 41.05 | 71.10 | 74.75 | 79.31 |
| 1994 | 608 | 29.61 | 10.69 | 13.84 | 17.43 | 26.97 | 7.40 | 11.41 | 13.98 | 43.42 | 70.72 | 74.76 | 79.28 |
| 1995 | 576 | 28.13 | 10.59 | 14.08 | 17.01 | 25.35 | 8.33 | 10.99 | 14.41 | 46.53 | 70.49 | 74.93 | 79.69 |
| 1996 | 571 | 31.17 | 10.86 | 14.23 | 19.79 | 21.72 | 7.88 | 10.88 | 14.36 | 47.11 | 68.30 | 74.88 | 78.63 |
| 1997 | 544 | 32.90 | 11.40 | 14.29 | 18.01 | 19.12 | 7.90 | 10.75 | 14.52 | 47.98 | 69.67 | 74.96 | 78.13 |
| 1998 | 517 | 33.85 | 9.86 | 13.88 | 17.99 | 22.82 | 8.70 | 11.33 | 16.25 | 43.33 | 70.79 | 74.79 | 79.11 |
| 1999 | 500 | 32.60 | 10.60 | 13.66 | 17.40 | 26.40 | 8.00 | 11.63 | 16.20 | 41.00 | 70.20 | 74.72 | 79.40 |
| 2000 | 433 | 33.26 | 9.70 | 12.71 | 16.17 | 26.56 | 8.55 | 12.23 | 16.17 | 40.18 | 69.75 | 75.06 | 79.91 |
| 2001 | 440 | 30.00 | 8.86 | 12.50 | 17.95 | 29.55 | 7.27 | 12.33 | 17.73 | 40.45 | 69.55 | 75.17 | 80.45 |
| 2002 | 453 | 26.05 | 8.61 | 12.57 | 16.11 | 26.49 | 8.39 | 12.64 | 16.11 | 47.46 | 69.32 | 74.79 | 80.57 |
| 2003 | 557 | 23.34 | 10.05 | 13.47 | 16.52 | 26.21 | 8.80 | 11.66 | 16.16 | 50.45 | 71.27 | 74.87 | 79.35 |
| 2004 | 577 | 26.00 | 11.09 | 14.65 | 17.85 | 27.21 | 8.15 | 10.49 | 14.73 | 46.79 | 69.32 | 74.86 | 80.24 |
| 2005 | 598 | 30.77 | 13.04 | 16.43 | 19.57 | 26.59 | 6.35 | 9.36 | 13.04 | 42.64 | 69.57 | 74.21 | 78.76 |
| 2006 | 655 | 31.45 | 12.37 | 16.97 | 20.46 | 23.36 | 7.18 | 9.18 | 12.21 | 45.19 | 69.92 | 73.85 | 78.17 |
| 2007 | 669 | 30.79 | 12.41 | 16.83 | 20.78 | 23.02 | 6.43 | 9.08 | 11.81 | 46.19 | 69.96 | 74.09 | 78.33 |
| 2008 | 302 | 29.80 | 11.59 | 16.59 | 21.85 | 27.15 | 4.97 | 9.21 | 13.58 | 43.05 | 68.21 | 74.20 | 80.46 |
| 2009 | 308 | 28.25 | 11.69 | 15.58 | 22.08 | 28.25 | 4.55 | 10.29 | 15.26 | 43.51 | 68.51 | 74.13 | 80.19 |

Table C.2 – Actual vs. simulated proportions of insurers with consistent and inconsistent underwriting performance (after accounting for product lines and states)

Insurers classified in year t as *CONSISTENT_BETTER* or *CONSISTENT_WORSE* have respectively only positive or only negative abnormal realized underwriting returns over the three-year period from $t - 2$ through t , while *INCONSISTENT* insurers have both. The abnormal realized underwriting return used in this simulation accounts for insurer business mix (both product lines and states in which an insurer operates). The columns labeled “Actual” show the actual proportions of U.S. P/L insurers falling into each category. The columns labeled “Simulated” report the results of the simulation designed to estimate what proportion of insurers would fall into each category if insurers did not differ with respect to underwriting discipline. The simulation generates 10,000 realizations for each annual proportion; columns “Mean”, “Min” and “Max” report the average as well as the smallest and the largest of these realizations for each category each year. For example, 29.67% of insurers are classified as *CONSISTENT_BETTER* in 1993, meaning that they have positive abnormal returns in each year from 1991 to 1993. The simulation predicts that only 12.23 to 18.01% of insurers could fall into this category in 1993 if there were no differences in underwriting discipline; under this hypothesis, the best guess for the proportion of insurers in this category would be 15.21%.

| Year | N firms | Proportion of insurers (%) | | | | | | | | | | | |
|------|---------|----------------------------|-----------|-------|-------|-------------------------|-----------|-------|-------|---------------------|-----------|-------|-------|
| | | <i>CONSISTENT_BETTER</i> | | | | <i>CONSISTENT_WORSE</i> | | | | <i>INCONSISTENT</i> | | | |
| | | Actual | Simulated | | | Actual | Simulated | | | Actual | Simulated | | |
| | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max | |
| 1993 | 883 | 29.67 | 12.23 | 15.21 | 18.01 | 22.54 | 7.70 | 9.95 | 11.89 | 47.79 | 71.57 | 74.85 | 78.60 |
| 1994 | 915 | 31.91 | 13.88 | 16.54 | 19.02 | 22.51 | 6.99 | 9.21 | 12.90 | 45.57 | 69.95 | 74.25 | 77.49 |
| 1995 | 896 | 27.90 | 12.17 | 14.65 | 18.97 | 21.65 | 8.15 | 10.65 | 13.39 | 50.45 | 70.98 | 74.69 | 78.68 |
| 1996 | 926 | 24.30 | 11.56 | 14.31 | 16.52 | 21.17 | 8.75 | 10.72 | 12.96 | 54.54 | 71.81 | 74.98 | 78.51 |
| 1997 | 921 | 25.73 | 11.73 | 14.38 | 17.37 | 21.06 | 8.58 | 10.58 | 14.12 | 53.20 | 71.34 | 75.03 | 78.18 |
| 1998 | 846 | 29.08 | 11.58 | 14.99 | 18.44 | 21.99 | 8.27 | 10.33 | 13.12 | 48.94 | 70.69 | 74.68 | 79.20 |
| 1999 | 824 | 32.89 | 12.38 | 15.83 | 19.42 | 23.54 | 7.28 | 9.71 | 12.38 | 43.57 | 70.02 | 74.46 | 77.67 |
| 2000 | 781 | 34.57 | 12.68 | 16.26 | 20.10 | 22.92 | 7.04 | 9.34 | 11.91 | 42.51 | 70.93 | 74.40 | 78.10 |
| 2001 | 807 | 34.70 | 13.26 | 17.20 | 20.94 | 20.69 | 6.20 | 8.54 | 10.78 | 44.61 | 70.38 | 74.26 | 78.19 |
| 2002 | 848 | 29.36 | 14.50 | 17.67 | 21.34 | 18.51 | 5.66 | 8.56 | 11.08 | 52.12 | 69.81 | 73.77 | 76.77 |
| 2003 | 957 | 25.91 | 13.27 | 16.27 | 19.23 | 17.14 | 7.00 | 9.30 | 11.08 | 56.95 | 71.26 | 74.43 | 77.22 |
| 2004 | 948 | 28.80 | 13.61 | 16.20 | 19.09 | 19.51 | 6.75 | 9.30 | 11.92 | 51.69 | 70.36 | 74.50 | 78.27 |
| 2005 | 955 | 30.47 | 13.51 | 16.40 | 19.06 | 21.47 | 6.91 | 9.28 | 11.73 | 48.06 | 70.68 | 74.33 | 78.53 |
| 2006 | 968 | 30.68 | 13.53 | 15.95 | 18.70 | 21.69 | 6.82 | 9.45 | 11.67 | 47.62 | 71.38 | 74.61 | 77.58 |
| 2007 | 971 | 28.63 | 11.23 | 14.54 | 16.89 | 22.25 | 8.14 | 10.45 | 12.87 | 49.12 | 71.78 | 75.02 | 78.06 |
| 2008 | 937 | 28.82 | 11.21 | 13.89 | 16.86 | 24.87 | 8.64 | 11.10 | 13.45 | 46.32 | 72.25 | 75.01 | 78.44 |
| 2009 | 914 | 29.87 | 11.60 | 14.92 | 17.72 | 22.76 | 7.77 | 10.17 | 13.02 | 47.37 | 71.12 | 74.91 | 79.87 |

Table C.3 – Persistence of differences in insurer underwriting performance over time (after accounting for product lines and states)

Insurers are categorized into *CONSISTENT_BETTER* and *CONSISTENT_WORSE* based on their underwriting performance in 2007-2009 (Panel A) or 2001-2003 (Panel B). The table shows each group's mean and median abnormal realized underwriting returns (*AUWRET*), in percent, which account for the proportions of premiums written by an insurer in each product line and state. The table also shows the percentage of insurers that have positive *AUWRET* in a given year. Differences in the mean (median) *AUWRET* between the two groups are determined by a *t*-test (Wilcoxon rank sum test). Differences in the percentage of insurers that have positive *AUWRET* in each year are determined by a chi-square test.

Panel A: Classification Based on 2007 to 2009

| Year | (a) <i>CONSISTENT_BETTER</i> | | | (b) <i>CONSISTENT_WORSE</i> | | | Diff.: (a) - (b) | | |
|------|------------------------------|-------|--------|-----------------------------|--------|--------|------------------|-----------|------------|
| | N | Mean | Median | N | Mean | Median | Mean | Median | % |
| 1991 | 154 | 2.55 | 2.31 | 116 | -1.20 | -1.47 | 3.75 ** | 3.78 ** | 15.57 ** |
| 1992 | 167 | 1.24 | 1.38 | 125 | 3.85 | 4.78 | -2.61 * | -3.40 * | -11.11 * |
| 1993 | 169 | 0.41 | 0.44 | 129 | 0.45 | 0.99 | -0.04 | -0.55 | -0.23 |
| 1994 | 190 | -0.31 | 0.75 | 131 | 0.66 | 3.03 | -0.98 | -2.29 | -10.73 * |
| 1995 | 197 | 2.07 | 2.33 | 141 | 0.52 | 0.46 | 1.55 | 1.86 | 9.45 |
| 1996 | 198 | 2.45 | 2.23 | 143 | -0.20 | 0.89 | 2.65 ** | 1.34 * | 5.44 |
| 1997 | 198 | 2.03 | 2.23 | 137 | 1.56 | 2.31 | 0.47 | -0.08 | -1.94 |
| 1998 | 206 | 1.05 | 1.69 | 148 | 2.59 | 2.44 | -1.54 | -0.75 | -8.17 |
| 1999 | 217 | -0.08 | 0.22 | 160 | 2.15 | 5.23 | -2.23 | -5.02 ** | -10.43 * |
| 2000 | 212 | 1.53 | 2.31 | 146 | 1.88 | 3.21 | -0.35 | -0.90 | -5.63 |
| 2001 | 233 | 0.47 | 1.47 | 170 | 0.86 | 2.12 | -0.39 | -0.66 | -3.67 |
| 2002 | 233 | 2.38 | 4.12 | 180 | -1.48 | -0.49 | 3.86 *** | 4.61 *** | 19.43 *** |
| 2003 | 238 | 2.80 | 4.29 | 190 | -0.74 | -0.99 | 3.55 *** | 5.28 *** | 17.13 *** |
| 2004 | 244 | 3.11 | 4.58 | 190 | -0.76 | -0.58 | 3.87 *** | 5.16 *** | 20.43 *** |
| 2005 | 249 | 3.95 | 5.39 | 197 | -1.93 | -1.73 | 5.88 *** | 7.11 *** | 30.45 *** |
| 2006 | 268 | 5.85 | 5.53 | 202 | -6.60 | -6.73 | 12.45 *** | 12.26 *** | 57.70 *** |
| 2007 | 273 | 10.31 | 8.61 | 208 | -11.85 | -7.88 | 22.15 *** | 16.49 *** | 100.00 *** |
| 2008 | 273 | 11.27 | 9.33 | 208 | -11.48 | -7.96 | 22.75 *** | 17.29 *** | 100.00 *** |
| 2009 | 273 | 11.77 | 9.35 | 208 | -13.23 | -9.10 | 25.00 *** | 18.45 *** | 100.00 *** |

Panel B: Classification Based on 2001 to 2003

| Year | (a) CONSISTENT_BETTER | | | (b) CONSISTENT_WORSE | | | Diff.: (a) - (b) | | |
|------|-----------------------|-------|--------|----------------------|--------|--------|------------------|-----------|------------|
| | N | Mean | Median | N | Mean | Median | Mean | Median | % |
| 1991 | 147 | 3.07 | 3.11 | 104 | -1.10 | 0.56 | 4.17 *** | 2.55 *** | 10.38 |
| 1992 | 164 | 3.47 | 3.87 | 114 | -1.75 | 1.46 | 5.22 *** | 2.41 *** | 13.10 ** |
| 1993 | 167 | 3.38 | 3.43 | 120 | -1.79 | -0.60 | 5.17 *** | 4.03 *** | 20.53 *** |
| 1994 | 180 | 2.96 | 3.43 | 127 | -2.13 | -0.38 | 5.09 *** | 3.81 *** | 17.29 *** |
| 1995 | 192 | 1.68 | 1.77 | 139 | -0.78 | 0.09 | 2.45 ** | 1.68 ** | 9.02 |
| 1996 | 198 | 3.62 | 2.58 | 140 | 0.36 | -0.20 | 3.25 *** | 2.77 *** | 15.78 *** |
| 1997 | 199 | 3.43 | 3.86 | 131 | -1.18 | 1.12 | 4.62 *** | 2.74 *** | 10.36 * |
| 1998 | 207 | 4.12 | 4.25 | 139 | -2.48 | -1.54 | 6.61 *** | 5.80 *** | 20.38 *** |
| 1999 | 221 | 5.73 | 5.98 | 147 | -3.37 | -3.25 | 9.10 *** | 9.23 *** | 34.53 *** |
| 2000 | 218 | 6.42 | 6.84 | 143 | -6.07 | -4.84 | 12.49 *** | 11.68 *** | 43.93 *** |
| 2001 | 248 | 11.26 | 8.77 | 164 | -10.68 | -6.34 | 21.94 *** | 15.12 *** | 100.00 *** |
| 2002 | 248 | 11.73 | 10.50 | 164 | -12.99 | -8.66 | 24.71 *** | 19.16 *** | 100.00 *** |
| 2003 | 248 | 10.07 | 8.42 | 164 | -11.13 | -9.13 | 21.21 *** | 17.55 *** | 100.00 *** |
| 2004 | 228 | 5.88 | 5.73 | 151 | -4.40 | -3.55 | 10.27 *** | 9.28 *** | 40.77 *** |
| 2005 | 227 | 3.09 | 3.48 | 150 | -2.71 | -1.94 | 5.80 *** | 5.43 *** | 24.07 *** |
| 2006 | 227 | 1.46 | 1.59 | 146 | -2.00 | -2.29 | 3.45 *** | 3.88 *** | 20.67 *** |
| 2007 | 224 | -0.23 | 0.44 | 137 | -0.39 | -1.70 | 0.16 | 2.14 | 12.25 ** |
| 2008 | 215 | 0.27 | 1.79 | 131 | -0.15 | -0.73 | 0.42 | 2.52 | 10.35 * |
| 2009 | 203 | 2.12 | 4.11 | 129 | -0.27 | -0.12 | 2.39 | 4.23 ** | 16.19 *** |

Table C.4 – Actual vs. simulated proportions of insurers with consistent and inconsistent underwriting performance (accounting for insurer characteristics)

Insurers classified in year t as *CONSISTENT_BETTER* or *CONSISTENT_WORSE* have respectively only positive or only negative abnormal realized underwriting returns over the three-year period from $t - 2$ through t , while *INCONSISTENT* insurers have both. The abnormal realized underwriting return used in this simulation accounts for insurer business mix (both product lines and states in which an insurer operates). The columns labeled “Actual” show the actual proportions of U.S. P.L. insurers falling into each category. The columns labeled “Simulated” report the results of the simulation designed to estimate what proportion of insurers would fall into each category if insurers did not differ with respect to underwriting discipline. This simulation separates insurers into buckets depending on their size quartile, organizational form and distribution system; the probability of a positive abnormal return is allowed to vary by bucket (and by year). The simulation generates 10,000 realizations for each annual proportion; columns “Mean”, “Min” and “Max” report the average as well as the smallest and the largest of these realizations for each category each year. For example, 29.67% of insurers are classified as *CONSISTENT_BETTER* in 1993, meaning that they have positive abnormal returns in each year from 1991 to 1993. The simulation predicts that only 11.66 to 20.61% of insurers could fall into this category in 1993 if there were no differences in underwriting discipline; under this hypothesis, the best guess for the proportion of insurers in this category would be 15.95%.

| Year | N firms | Proportion of insurers (%) | | | | | | | | | | | |
|------|---------|----------------------------|-------|-----------|-------|-------------------------|------|-----------|-------|---------------------|-------|-----------|-------|
| | | <i>CONSISTENT_BETTER</i> | | | | <i>CONSISTENT_WORSE</i> | | | | <i>INCONSISTENT</i> | | | |
| | | Actual | | Simulated | | Actual | | Simulated | | Actual | | Simulated | |
| Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | | |
| 1993 | 883 | 29.67 | 11.66 | 15.95 | 20.61 | 22.54 | 6.91 | 10.38 | 14.72 | 47.79 | 67.50 | 73.67 | 79.16 |
| 1994 | 915 | 31.91 | 12.68 | 16.77 | 21.20 | 22.51 | 6.23 | 9.63 | 13.11 | 45.57 | 67.98 | 73.60 | 79.13 |
| 1995 | 896 | 27.90 | 11.05 | 15.01 | 19.42 | 21.65 | 6.81 | 10.66 | 14.73 | 50.45 | 68.64 | 74.34 | 80.02 |
| 1996 | 926 | 24.30 | 10.69 | 14.93 | 19.33 | 21.17 | 7.24 | 11.13 | 14.58 | 54.54 | 68.47 | 73.94 | 79.48 |
| 1997 | 921 | 25.73 | 10.42 | 14.91 | 19.76 | 21.06 | 7.06 | 10.99 | 15.42 | 53.20 | 68.19 | 74.10 | 79.37 |
| 1998 | 846 | 29.08 | 10.76 | 15.52 | 20.57 | 21.99 | 6.97 | 10.90 | 15.48 | 48.94 | 67.26 | 73.58 | 79.43 |
| 1999 | 824 | 32.89 | 12.38 | 16.97 | 21.72 | 23.54 | 6.55 | 10.55 | 15.29 | 43.57 | 66.38 | 72.48 | 78.88 |
| 2000 | 781 | 34.57 | 12.93 | 17.66 | 22.92 | 22.92 | 6.15 | 10.53 | 14.34 | 42.51 | 65.94 | 71.81 | 77.98 |
| 2001 | 807 | 34.70 | 14.13 | 18.85 | 25.03 | 20.69 | 5.82 | 9.62 | 13.75 | 44.61 | 65.30 | 71.53 | 77.70 |
| 2002 | 848 | 29.36 | 12.85 | 17.53 | 22.17 | 18.51 | 4.95 | 8.31 | 12.26 | 52.12 | 68.04 | 74.16 | 80.42 |
| 2003 | 957 | 25.91 | 12.02 | 16.23 | 20.79 | 17.14 | 5.75 | 9.18 | 12.96 | 56.95 | 69.28 | 74.60 | 80.88 |
| 2004 | 948 | 28.80 | 12.24 | 16.99 | 21.94 | 19.51 | 6.86 | 10.16 | 14.14 | 51.69 | 67.51 | 72.85 | 77.85 |
| 2005 | 955 | 30.47 | 12.25 | 16.51 | 20.63 | 21.47 | 6.07 | 9.61 | 13.30 | 48.06 | 68.48 | 73.87 | 78.64 |
| 2006 | 968 | 30.68 | 12.50 | 16.54 | 21.28 | 21.69 | 6.20 | 9.86 | 13.33 | 47.62 | 68.39 | 73.60 | 78.82 |
| 2007 | 971 | 28.63 | 10.30 | 15.29 | 20.08 | 22.25 | 7.62 | 11.02 | 14.83 | 49.12 | 68.28 | 73.70 | 79.20 |
| 2008 | 937 | 28.82 | 10.78 | 14.54 | 19.10 | 24.87 | 7.68 | 11.57 | 15.69 | 46.32 | 67.66 | 73.90 | 79.08 |
| 2009 | 914 | 29.87 | 10.72 | 15.47 | 20.13 | 22.76 | 6.13 | 10.27 | 13.89 | 47.37 | 68.05 | 74.26 | 79.43 |

Table D.1 - Average values of insurer characteristics by the level of underwriting discipline.

This table shows the average values of insurer characteristics by level of underwriting discipline, defined as *UWD_CAT*. Insurer characteristics are measured at the end of year *t*, *UWD_CAT* is measured over the next five years (*t*+1 through *t*+5). See Table 9 for more information about each variable.

| | <i>UWD</i> | | | |
|-------------------------|----------------|-----------------|-----------------|-------------------|
| | <i>STRONG</i> | <i>MEDIUM</i> | <i>WEAK</i> | <i>INCONSIST.</i> |
| % mutual | 0.26 | 0.34 | 0.34 | 0.26 |
| % affiliated | 0.76 | 0.81 | 0.78 | 0.63 |
| % ind. agent | 0.79 | 0.80 | 0.85 | 0.77 |
| Size | 18.68 (1.7) | 18.92 (1.69) | 18.68 (1.72) | 18.06 (1.58) |
| Leverage | 1.34 (0.72) | 1.39 (0.66) | 1.32 (0.72) | 1.08 (0.77) |
| NPW growth | 0.10 (0.21) | 0.09 (0.19) | 0.07 (0.21) | 0.09 (0.29) |
| Reins. ceded | 0.34 (0.27) | 0.36 (0.26) | 0.36 (0.26) | 0.37 (0.26) |
| Product diversification | 0.51 (0.32) | 0.60 (0.29) | 0.59 (0.31) | 0.52 (0.32) |
| Geo. diversification | 0.46 (0.39) | 0.52 (0.36) | 0.52 (0.36) | 0.41 (0.38) |
| % personal lines | 0.50 (0.4) | 0.52 (0.37) | 0.46 (0.38) | 0.33 (0.38) |
| % longtail lines | 0.68 (0.21) | 0.67 (0.18) | 0.70 (0.17) | 0.69 (0.27) |
| % catastrophe | 0.02 (0.08) | 0.02 (0.05) | 0.02 (0.06) | 0.03 (0.11) |

Table D.2 - Multinomial logistic regression of *UWD_CAT* on insurer characteristics

The categorical measure of underwriting discipline *UWD_CAT* has four categories: *STRONG* (chosen as base), *MEDIUM*, *WEAK* and *INCONSISTENT*. Firm characteristics are at the end of year t , *UWD_CAT* is measured over the next five years ($t+1$, $t+5$). See the note to Table 9 for the definitions of firm characteristics. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.1 level.

| | Relative log odds | | | | | |
|------------------------|-------------------------------|----------|---------------------------------|----------|---------------------------------------|----------|
| | <i>WEAK</i> vs. <i>STRONG</i> | | <i>MEDIUM</i> vs. <i>STRONG</i> | | <i>INCONSISTENT</i> vs. <i>STRONG</i> | |
| | Coef. | SE | Coef. | SE | Coef. | SE |
| Mutual | 0.50 | 0.08 *** | 0.52 | 0.07 *** | -0.35 | 0.08 *** |
| Affiliated | 0.46 | 0.09 *** | 0.51 | 0.09 *** | -0.14 | 0.09 |
| Independent Agent | 0.27 | 0.09 *** | 0.02 | 0.08 | -0.21 | 0.08 ** |
| Size | 0.05 | 0.03 * | 0.08 | 0.02 *** | -0.07 | 0.03 *** |
| Concentration: | | | | | | |
| Product | -0.47 | 0.12 *** | -0.78 | 0.11 *** | -0.41 | 0.12 *** |
| Geographical | -0.46 | 0.11 *** | 0.03 | 0.10 | 0.08 | 0.11 |
| AM Best rating | -0.42 | 0.03 *** | -0.21 | 0.02 *** | -0.45 | 0.03 *** |
| Reinsurance ceded | 0.15 | 0.14 | 0.45 | 0.13 *** | 0.21 | 0.14 |
| Growth | -0.81 | 0.20 *** | -0.51 | 0.19 *** | -0.71 | 0.19 *** |
| Growth ^{^2} | 0.54 | 0.26 ** | 0.19 | 0.24 | 1.05 | 0.22 *** |
| Leverage | -0.38 | 0.15 ** | 0.47 | 0.15 *** | -1.73 | 0.13 *** |
| Leverage ^{^2} | -0.02 | 0.05 | -0.15 | 0.04 *** | 0.29 | 0.04 *** |
| | N = 8,325 | | Pseudo R-sq. = 0.07 | | Year FE included | |