Opaque Insurer Liabilities, Learning, and the Cost of Equity Capital

Chia-Chun Chiang, Hugh H. Kim, Greg Niehaus

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Abstract

Insurers are often considered as investment companies with leverage. We empirically investigate the role of insurers as liability managers (underwriters), rather than asset managers (investors) by focusing on the determinants of their cost of equity capital. Analyzing the top 100 U.S. property-liability insurers, we find that the cost of equity capital is negatively related to insurers' underwriting performance, but not their investment performance. This difference is attributable to opaque insurer liabilities and investor learning. We also find that capital market and product market imperfections are important determinants of insurers' cost of capital. Overall, our findings support the traditional view of insurers as underwriters, rather than investors.

JEL: G22, G12, G31

Keywords: insurer underwriting performance, cost of equity capital, asset pricing, opacity

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Chiang is affiliated with the University of Texas at El Paso. 500 West University Avenue, El Paso, TX 79968. Kim and Niehaus are affiliated with the Darla Moore School of Business, University of South Carolina. 1014 Greene St., Columbia, SC 29208. Email: chia-cchiang@utep.edu, hugh.kim@moore.sc.edu and gregn@moore.sc.edu. The authors appreciate the comments of Xin Che, Thomas Berry-Stolze and participants at the 2018 American Risk and Insurance Association Meeting and the seminar at the University of South Carolina.

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> *"Disciplined risk evaluation is the daily focus of all of our insurance managers. [Float's] benefit can be drowned by poor underwriting results. All insurers give that message lip service. At Berkshire it is a religion, Old Testament style."*
>
> Warren Buffett, Berkshire Hathaway's 2016 Annual Report

1. Introduction

From a financial asset management perspective, insurance companies are just leveraged investment firms, i.e., they "borrow" from policyholders and use these borrowed funds (sometimes referred to as "float") to invest in financial securities. In this view, there is no difference between insurers and other investment firms with leverage, such as hedge funds or private equity firms. Indeed, this is how analysts often describe Warren Buffett's success: he has leveraged his superior investment skills with float from his insurance subsidiaries.[1] A recent Ernst & Young (2015) report supports the growing acceptance of this view in the industry: "The financial areas of the [insurance] company have risen to greater visibility and power, while the management profile of underwriting has dipped noticeably." The increased emphasis on insurer asset management would suggest that the asset management side of the business, as opposed to the traditional underwriting side of the business, is most responsible for value creation of insurers. Interestingly, Warren Buffett does not share this view, as the above quoted statement indicates.[2]

We find that estimates of the cost of equity capital for property-liability insurers (based on traditional asset pricing models and implied cost of capital models) are significantly negatively related to the prior quarter's reported underwriting performance, i.e., poor underwriting results are associated with subsequent increases in the cost of capital. Specifically, a one-standard-deviation decrease in the quarterly underwriting return on assets is associated with an economically significant increase in the annual cost of capital of between 46 and 115 basis points, depending on the cost of capital estimation method. We do

[1] See e.g., Worstall (2013). Frazzini et al. (2013) analyze Buffetts' investment performance, and present evidence that Berkshire Hathaway's superior performance is due to its abiity to leverage its stock picking ability of publicly traded companies as opposed to its management of private companies. The asset management perspective is also used to explain why hedge funds have combined with insurer/reinsurers in the past two decades, although taxes also play an important role in these transactions. See e.g., Reactions (2014) and Briefing (2016).

[2] Also, see the discussion of insurance in the Chairman's letter in Berkshire Hathaway's 2016 Annual report.

not, however, find that the cost of equity capital is significantly related to investment performance reports. These findings provide new evidence on the importance of liability management (underwriting) for insurers.

We suggest that the difference in how the cost of capital responds to underwriting performance versus investment performance is due to the relative opacity of insurer liabilities compared to their assets. Underwriting often involves the use of "soft information," i.e., information that is not easily quantifiable, requires judgment and skill to interpret, and is difficult to communicate (Liberti and Petersen, 2017). Moreover, it is difficult for investors to judge the skills and effort of the insurer in assessing, selecting, and pricing the risk exposures that are insured. As a consequence, the true underlying expected payout on liabilities is unknown, and investors learn about the expected payouts on liabilities over time as claim costs are revealed (Pastor and Veronesi, 2009).[3] Importantly, for many lines of insurance, the revelation of underwriting performance provides information not only about the underwriting return during the reporting period on outstanding liabilities (policies issued in the past), but also about the future expected return on policies issued in the past and potentially on the policies to be issued in the future. As a result, information provided by underwriting performance reports can have a substantial impact on an insurer's financial leverage, which in turn affects the cost of equity capital.

In contrast, investment performance reports provide limited information about the skills and effort of the investment management team; instead, investment performance reports are likely to provide information mostly about the transitory unexpected returns during the reporting period, which are not expected to persist. Consistent with this interpretation, the extant mutual fund literature presents evidence that mutual funds' performance is not persistent after controlling for momentum factors (e.g., see Gruber, 1996; Carhart, 1997; Wermers, 2000; Fama and French, 2010; Edelen, Ince, and Kadlec, 2016; Chakrabarty, Moulton, and Trzcinka, 2017). In addition, information about insurers' asset portfolios is readily available in various sources such as financial institutions investment disclosure forms (e.g., SEC 13F form). In sum, we posit that insurers' assets are less opaque, thus asset performance reports provide limited information about an insurer's current and future leverage ratio.

[3] Insurance underwriting is akin to relationship lending of banks to small firms (see e.g., Petersen and Rajan, 1994, Berger and Udell, 1995). To be sure, insurer liabilities are not homogeneous. For some types of liabilities (e.g., auto physical damage policies), estimating the expected value of claim costs is likely to involve objective data that is readily available, but for other liabilities (e.g., commercial liability policies), soft information is likely to be useful and judgment is needed to interpret such information.

Our results also indicate that market imperfections are key channels through which underwriting performance affects insurers' cost of capital.[4] First, we show that there is an asymmetric relationship between underwriting performance and the cost of equity capital: greater underwriting losses are associated with increases in the cost of equity, but greater underwriting profits do not lead to a similar decrease in the cost of equity. When market imperfections cause the firms' value function to be concave (see Froot, Scharfstein, and Stein, 1993, Froot and Stein, 1998, and Froot 2007), losses reduce the economic value of capital more than an equal amount of profits increase value. As a consequence, we expect an asymmetry in the impact of bad versus good performance on financial leverage. The asymmetric relationship between underwriting performance and the cost of equity capital therefore is consistent with market imperfections, such as financial distress costs, costs of holding capital (e.g., taxes) and costs of raising capital (Froot and Stein, 1998). Second, we show that the impact of poor underwriting performance on the cost of capital is more pronounced for insurers that have a low S&P financial strength rating. This finding is consistent with the cost of capital increasing more when insurers have greater financial distress costs. Third, using implied cost of capital estimates, we find that underwriting performance is negatively related to the cost of capital even after controlling for the impact of performance on estimated risk loadings. This finding is consistent with leverage increasing the cost of capital via increased market imperfection costs, in addition to the increased risk loadings channel.

If differential opacity and learning explain the differential effect of underwriting and investment performance on the cost of capital, then one might expect that performance reports would convey more information about firms with less financial analyst coverage. Correspondingly, one might expect that the impact of underwriting performance on the cost of capital is more pronounced for insurers with less analyst coverage. We find mixed evidence regarding this prediction. One explanation is that the information produced by financial analysts do not substitute for the information investors infer from insurers' underwriting performance.

The relative unresponsiveness of the cost of capital to information about investment performance has similarities to Chodorow-Reich, Ghent, and Haddad's (2016) findings that life insurer equity values do not typically respond dollar for dollar to changes in the value of the assets in the life insurers' portfolios.

[4] Campbell, Dhaliwal, and Schwartz (2012) provide evidence that mandatory pension contributions increase a firm's cost of capital and attribute the change in part to market imperfections.

Their argument applies more to life insurers whose asset portfolios typically consist of mostly long-term, relatively illiquid bonds. As we show, the effect documented in this paper is largely due to property/liability (P/L) insurers, that typically hold more equity and more liquid securities. Also, Chodorow-Reich, Ghent, and Haddad (2016) show that the asset insulation declines during the financial crisis. We do not find that our main results differ during the financial crisis.

The paper has several implications for academics and practitioners. First, the research brings additional attention to the role of insurers as underwriters and what makes them different from leveraged asset managers. The evidence suggests that the greater opacity of insurer liabilities compared to assets plays an important role in the insurance business. As a result, we contribute to the literature highlighting the underwriting role of insurers in assessing and managing opaque liabilities (e.g., Kamiya and Milidonis, 2016, Eckles, Halek, Sommer, and Zhang, 2011, and Zhang, Cox, and Van Ness, 2009, and Morgan, 2002). Second, there is a large literature on understanding the firm- and market-level determinants of insurers' cost of capital (e.g., Cummins and Phillips, 2005, Eckles, Halek and Zhang, 2014). This is because the cost of capital is an important input for a variety of financial decisions, including capital budgeting, capital structure, valuation, and performance assessment. In regulated industries, such as insurance, the cost of capital is also a public policy issue because it can affect rate regulation. Our results suggest that market imperfection costs are an important component of insurers' cost of capital and that insurers should consider updating their cost of equity capital estimates to take into account recent underwriting performance. Third, we contribute to the literature on learning in financial markets by adding another example of how parameter uncertainty and investor learning can help us better understand financial markets and institutions (Pastor and Veronesi, 2009).

The paper proceeds as follows. In the next section, we develop the hypotheses based on related literature. In section 3, we describe the data. In section 4, we present the empirical results. In the final section, we conclude by summarizing the results and discussing potential implications of the opacity of insurer liabilities.

2. Hypothesis development

We begin with a simple perfect markets framework and review how the expected equity returns (cost of equity capital) of an insurer vary with the firm's leverage ratio. We then discuss market imperfections and their impact on firms' leverage and the cost of capital. Finally, we discuss how insurer performance reports can provide information about financial leverage that would alter an insurer's cost of capital.

2.1 Leverage and the cost of equity capital in an imperfect market setting

Let A equal the market value of the insurer's assets and L equal the market value of the insurer's liabilities. Then the value of equity claims, E, equals $A – L$ and the return on equity equals

$$r_E = r_A (A/E) – r_L (L/E), \quad (1)$$

where r_E, r_A, and r_L denotes the rate of return on equity, assets, and liabilities, respectively.

Conventional financial asset pricing models imply that the expected returns equal the risk-free return plus a risk premium that is determined by the amount of systematic risk. Thus, we can write

$$E[r_E]= (r_f + \beta_A E[rp]) (A/E) – (r_f + \beta_L E[rp]) (L/E) , \quad (2)$$

where the β_A and β_L represent the amount of systematic risk for assets and liabilities, respectively, and rp is the compensation per unit of risk. At this stage, we are not specifying a particular asset pricing model, although we accept that only systematic risk is priced and that the amount of systematic risk is linearly related to expected returns. If more than one type of systematic risk measure is relevant, the β and rp terms can be interpreted as vectors. Rearranging terms yields

$$E[r_E]= r_f + [(\beta_A - \beta_L)(A/E) + \beta_L] E[rp]. \quad (3)$$

The term in brackets is the insurer's sensitivity to the risk factor(s); it depends on the systematic risk of assets (β_A), the systematic risk of liabilities (β_L), and the firm's financial leverage (A/E). Evidence indicates that most of the risk associated with P/L liabilities is diversifiable.[5] Therefore, we assume that $\beta_A > \beta_L$.

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[5] Barinov, Pottier, and Xu (2018) present evidence that aggregate underwriting profit/loss pattern in the industry is not correlated with the macro risk factors.

Froot and Stein (1998) analyze how financial market imperfections associated with costly external financing (e.g., asymmetric information and transaction costs) and costs of holding capital (e.g., tax and agency costs) influence insurer investment, capital, and risk management decisions. Froot (2007) adds insurance product market imperfections that arise from insurance consumers' high sensitivity to insurers' financial stability (Hoerger, Sloan, and Hassan, 1990). Despite efforts of insurers to manage them (e.g., by their choice of leverage and risk), the costs of these market imperfections cannot be eliminated, and consequently equity capital providers require compensation for these costs beyond what they would demand in a perfect capital market. To incorporate these costs in a simple manner, we add a term, *MIC* (market imperfection costs) to the perfect markets cost of capital expression (Equation (3)):

$$E[r_E] = r_f + [\ (\beta_A - \beta_L)(A/E) + \beta_L\ ]\ \mathrm{E}[rp] + MIC\ . \qquad (4)$$

The market imperfection cost (*MIC*) added to the cost of equity capital is akin to the additional term added to the traditional hurdle rate for capital budgeting purposes in the Froot and Stein (1998) model. The additional term in the hurdle rate equals the amount of additional firm-specific risk that is due to the project under consideration times the cost per unit of firm-specific risk, which is denoted by *G* in Froot and Stein (1998). They show that the cost per unit of firm-specific risk increases monotonically as leverage increases. Intuitively, leverage increases the expected future costs associated with raising external capital and lower product demand. We therefore assume that *MIC* is an increasing function of the firm's asset to equity ratio (*A/E*).

Holding the systematic risk of assets and liabilities (the β's) constant, an increase in the firm's asset to equity ratio (*A/E*) implies that the cost of equity will increase, i.e.,

$$\mathrm{dE}[r_E]/\mathrm{d}(A/E) = (\beta_A - \beta_L)\ \mathrm{E}[rp] + \mathrm{d}MIC/\mathrm{d}(A/E) > 0\ . \qquad (5)$$

The first term, $(\beta_A - \beta_L)$ E[*rp*] is the pure leverage effect on the expected equity returns in a perfect market setting (Modigliani and Miller, 1958) and the second term, d*MIC*/d(*A/E*) is the additional risk premium arising from imperfections in the capital and product markets (Froot and Stein, 1998; Froot, 2007). This analysis implies that, in an imperfect market setting, the expected return on equity will increase as the insurer's leverage increases and the magnitude of the change is greater than suggested in the perfect market setting.

2.2 Opaque insurer liabilities, learning, and leverage

Insurers' underwriting performance is an important determinant of a firm's leverage ratio. A crucial feature of insurer underwriting performance is its opacity. By opacity, we mean that investors have uncertainty about the underlying process that generates cash flows. The notion of opacity in this paper relates to related literature on "parameter uncertainty" and "information risk" (e.g., Eckles, Halek and Zhang, 2014 and Chen, Lu, and Weiss, 2017). For simplicity, we assume that opacity is innate, i.e., the underlying parameters of the probability distributions determining cash flows is unknown to everyone (Lambert, Leuz, and Verrecchia, 2007). This might apply, for example, to underwriting of natural catastrophes, or emerging risks such as cyber exposures, or to commercial liability exposures.[6]

There is ample evidence that the insurance business, especially the liability-side (underwriting process), is opaque. Morgan (2002) measures the opaqueness of various industries using the extent to which rating agencies differ in their ratings of new bond issues (so-called split ratings). He finds that insurance and banking are the industries with the most split ratings, with insurance being even higher than banks.[7] Zhang , Cox, and Van Ness (2009) provide evidence on the opacity of publicly traded property and liability (P/L) and life insurance companies by using the adverse selection component of bid/ask spreads. They classify insurers' assets and liabilities as either opaque or transparent and show that bid/ask spreads increase with the percentage of P/L insurer liabilities classified as opaque, but that bid/ask spreads do not increase with P/L insurer assets or life insurer liabilities that are classified as opaque. Eckles, Halek and

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[6] Opacity can also be created by managers. For example, Babbel and Merrill (2005) discuss how insurance companies can distort information to make the value of assets and liabilities more opaque. Evidence exists that managers influence reported reserves in efforts to affect their compensation (Eckles, Halek, Sommer, and Zhang, 2011), and the firm's tax payments (Weiss, 1985), solvency measures (Gaver and Paterson, 2004), and price regulation (Grace and Leverty, 2010). Importantly, this leads to asymmetric information between company managers and investors. Easley, Hvidkjaer and O'Hara (2002) and Easley and O'Hara (2004) analyze how asymmetric information affects the cost of capital. To keep the story simple, we abstract from these issues.

[7] Pottier and Sommer (2006) use a similar methodology to identify chacteristics of insurers that are associated with split ratings.

Zhang (2014) and Chen, Lu, and Weiss (2017) use the standard deviation of insurer loss reserve errors as a proxy for information risk and examine whether insurers' cost of capital varies with this measure.

The opaque nature of insurer liabilities and underwriting performance can influence investors' perception of an insurer's current and future financial leverage through investor learning. Conceptually, we identify three channels by which underwriting performance can influence investors' perception of an insurer's financial leverage. The simple model in Appendix A more formally develops the three channels discussed here. First, if we view the cash flows from liabilities as being equal to a known constant mean plus a transitory error term, then the realization of underwriting profits in a given quarter informs investors about the realization of the error term for that quarter. If claim costs are higher than expected (the error term is positive), then investors will understand that equity will be reduced commensurately and financial leverage will increase (provided the firm does not raise capital through some other means). In this case, the information provided by the underwriting report will not change the future expected cash flows from liabilities.

Second, suppose that the cash flows from liabilities in a given period are uncertain, but the mean of the distribution is unknown. We assume that managers and investors have a prior expectation about the mean and they update their view of the mean based on an insurer's underwriting report. The revised belief on the mean will lead investors to update their view of the expected cash flows (claims) on policies that have been written in the past on which claims will be paid in the future. In other words, the revised mean impacts the loss reserve on policies that have already been written. This effect could potentially cause a larger change in economic capital (assets minus liabilities) than the first channel, as it represents a permanent change in the expected value of cash flows from existing liabilities, not just the realization of temporary unexpected cash flows during one period.

A permanent change in the expected value of claim costs would also lead investors to update their view of the expected claims on policies written in the future, which is the third channel. This channel differs from the second in that the policies have not yet been sold. Provided insurers price these new policies consistent with the updated expectations and maintain the same markup relative to expected costs, then any change in expected future claims will be offset by a commensurate change in premiums and there would be minimal effects on financial leverage.[8] On the other hand, if either of the two conditions stated above does not apply and premiums do not adjust fully to the new expectations, there will be a change in economic capital. For example, suppose that negative underwriting profits increase the expected claim costs on new policies, but premiums do not increase commensurately, then economic capital will be depleted. One reason that premiums would not increase commensurately is that consumer demand is sensitive to insolvency risk and therefore the demand for policies declines as an insurer's financial leverage increases (see, e.g., Froot, 2007 and references therein). Note that this creates a feedback effect: reported underwriting losses increase leverage, which lowers demand, which increases leverage further.

The conclusion of this discussion is that the revelation of underwriting performance will lead investors to change their assessment of the firm's leverage ratio, which in turn will change the cost of capital for the reasons discussed in the previous sub-section. This yields the following testable hypothesis:

***Hypothesis 1*:** The cost of equity capital is negatively related to underwriting performance.

One can posit that investment performance of insurers (e.g., dividend/interest income, or capital gains) would also affect the leverage ratio in a similar manner as underwriting performance. However, there are at least two reasons to expect that the revelation of investment performance will *not* substantially change investors' views of the insurer's financial leverage ratio. First, the type of information that is revealed from investment performance is primarily information about the unexpected transitory return for the given period, not about the permanent return that can be expected over time. Indeed, there is substantial evidence in the literature on the lack of persistent abnormal performance of stock mutual fund managers after controlling for momentum factors (see Gruber, 1996; Carhart, 1997; Wermers, 2000; Fama and French, 2010; Chakrabarty, Moulton, and Trzcinka, 2017). Similarly, most evidence indicates a lack of persistence in the abnormal performance of bond mutual fund managers (Cici and Gibson, 2012), although there are

[8] If assets and liabilitiies increase by the same absolute amount, the asset to equity ratio will increase.

exceptions (Gutierrez, Maxwell, and Xu, 2008). Assuming insurer asset management teams are no better on average than mutual fund managers, we do not expect insurer investment performance to be persistent.

Second, the information provided by a quarterly report about the transitory component of investment performance is likely to be minimal because information about insurers' asset portfolios is readily available and there is public information about the returns of the asset classes in which insurers typically invest.[9] For these reasons, quarterly announcements of investment performance are not likely to lead investors to change substantially their view of a firm's leverage and therefore not update their view of a firm's cost of equity capital. This discussion, therefore, yields the following opposing hypotheses:

Hypothesis 2a**:** The cost of equity capital is negatively related investment performance.
Hypothesis 2b**:** The cost of equity capital is not related to investment performance.

With market imperfections, the impact of an insurer's leverage on the cost of capital is asymmetric to good versus bad performance. In the Froot and Stein (1998) and Froot (2007) framework, if future cash flows are low, insurers will incur additional costs because they will either need to raise costly external capital or forego positive net present value projects. In addition, low future cash flows will negatively affect consumer demand because of the increased default risk (Froot, 2007). As a consequence, firm value is a concave function of cash flow outcomes -- bad outcomes reduce value more than good outcomes increase value. This asymmetric payoff provides an incentive for firms to reduce firm level risk and it implies that poor operating performance will have a greater impact on the market value of equity capital than good operating performance of an equivalent magnitude. This in turn implies that there will be an asymmetric relationship between operating performance and financial leverage (measured using market value) and therefore an asymmetric relationship between operating performance and an insurer's cost of capital – poor performance will increase the cost of capital more than good performance of an equivalent magnitude will lower the cost of capital.

[9] The NAIC annual statements provide information about insurer portfolios and the U.S. Security and Exchange Comissions (SEC) mandates all institutional investors (including insurers) with more than $100 million assets to report their stock holdings (form 13F).

Additionally, the negative impact of leverage on the cost of capital is amplified when the financial stability of insurers is low. When an insurer is already financially weak, bad performance reduces value more than that for a firm that is financially strong, all else equal. Consequently, we expect that the impact of poor performance on the cost of capital would be greater for financially weak insurers.

To summarize, we have the following hypotheses:

Hypothesis 3: The relationship between poor underwriting performance and the cost of capital is stronger than for good performance.

Hypothesis 4: The relationship between poor underwriting performance and the cost of capital is stronger for insurers that are financially weak.

If investor learning is an important channel through which underwriting performance affects the cost of capital, then variation in the amount of information available to investors from other sources would affect how much underwriting performance influences the cost of capital. Using the number of analysts covering a firm as a proxy for the amount of information available to investors about the insurers' opaque liability, we have the following hypotheses:

Hypothesis 5**:** The impact of reported underwriting performance on the cost of equity capital is mitigated for insurers with high analyst coverage.

This hypothesis is based on the idea that the information produced by financial analysts is a substitute for the information that investors (and analysts) infer from insurers' reported underwriting performance. However, if the information produced by financial analysts is not informative about the opaque liability of insurers, then the moderating impact of analysts coverage would not be sizable.

3. Data and methodology

Quarterly performance data for individual insurers are from Verisk Analytics Inc.'s Top 100 Insurer Financial Results. They provide quarterly underwriting and financial data for the 100 largest U.S. property and casualty insurance companies. We merge the quarterly performance data with annual accounting information from the Compustat database. Daily stock price and return data for each firm are obtained from the Center for Research in Security Prices (CRSP). We have reliable data from all data sources for 92 publicly listed, property and casualty insurance companies in the U.S. from 1995Q1 through 2016Q3. Our analyses include market-wide variables which are from the St. Louis Federal Reserve Bank website. Recession periods in the US are obtained from National Bureau of Economic Research (NBER).

We estimate the costs of equity capital over quarterly intervals using various financial asset pricing models to show that our results are not dependent on one specific model. For each firm, we estimate quarterly factor loadings for CAPM, Fama-French 3-factor model (Fama and French, 1992), and a 4-factor model with a liquidity factor (Pastor and Stambaugh, 2003).[10] We estimate quarterly factor loadings based on the comovement of insurers' daily stock returns and daily factor returns during periods from the insurer's filing date of its quarterly underwriting results to the next quarterly underwriting results filing date.[11] The non-overlapping sample period for factor loading estimations decreases the likelihood that the resulting cost of capital estimates are influenced by previous performance announcements. When estimating factor loadings, we employ a sum-beta approach to adjust for infrequent trading of insurer stocks (Scholes and Williams, 1977; Dimson, 1979; Cummins, Phillips, 2005).[12] After estimating the loadings on all factors, we estimate the cost of equity capital based on historical annualized returns of factors, HML, SML and LIQ (from 1926 to 2016) and market risk premium of 4.02% reported by Graham and Harvey (2016) who surveyed chief financial officers (CFOs) in U.S. Cost of capital is calculated as the sum of risk-free rate (annualized T-bill rate with 30 days maturity) and the estimated factor loadings for each firm/quarter multiplied by the historical annualized factor returns.[13]

The key explanatory variables in our analysis are the insurer's underwriting and investment performance over the prior quarter. Our overall measure of underwriting performance is *Underwr_ROA*,

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[10] Including the momentum factor (Carhart, 1997), we have quantitatively and qualitatively similar results.
[11] In a robustness test, we use a two week window for investors to fully accommodate the new information and estimate the factor loadings after two weeks from the filing date until the next filing date. Results are similar and available upon request.
[12] The sum-beta approach includes lagged factor loadings in the traditional linear factor models. Our results are similar when the models are estimated in a conventional way without the sum-beta approach. Results available upon request.
[13] As a robustness check, we use time-varying factor premiums based on 20 year rolling-window averages, and the results are similar.

defined as underwriting profit scaled by total admitted assets. Underwriting profit is calculated as one minus the sum of the *Loss ratio* and the *Expense ratio* multiplied by earned premiums. The *Loss ratio* is defined as the ratio of losses and loss adjustment expenses to earned premiums. The *Expense ratio* is the ratio of underwriting expenses to written premiums.[14]

To measure investment performance we use three variables: *Investment income* is the ratio of net investment income, primarily dividends from stocks and interest on bonds, to total admitted assets. *Realized capital gains* is the ratio of realized capital gains to total admitted assets and *Unrealized capital gains* is the ratio of unrealized capital gains to total admitted assets. The sum of these three variables is the investment return on assets, denoted as *Inv_ROA*. Other variables used in our analysis are defined in Appendix B.

Table 1 presents descriptive statistics for the pooled sample of firm-quarter observations. The average (median) *Underwr_ROA* is 0.1 percent (0.2 percent) and the standard deviation is 1.6 percent. The components of the *Underwr_ROA* are 71 percent for the *Loss ratio* and 28.8 percent for the *Expense ratio* on average.

The averages of the quarterly *Investment income*, *Realized*, and *Unrealized capital gains* are 0.9, 0.1, and 0.03 percent, respectively. Adding the three sources of investment earnings, we find that the average quarterly investment return on assets (*Inv_ROA*) is 1.1 percent and the standard deviation is 1.5 percent.

The average cost of capital is between 6.9 percent to 11.1 percent, depending on asset pricing model used for estimation. The average loading on the market risk factor is 0.86, consistent with Cummins and Phillips (2005), who estimated CAPM with a sum-beta approach from 1997 through 2000. When estimated with the Fama-French 3 factors and the liquidity factor, the average factor loadings for market risk remains about the same (0.90). The insurers in our sample have positive value factor (HML) loadings on average, 0.63 and 0.64 for the 3-factor model and 4-factor model, respectively. To the extent that the value factor is proxying for potential distress risk (Fama and French 1995), the positive loading implies that distress risk

[14] Although the denominators of the ratios are not the same, the industry convention is to simply add the components.

is one of the major concerns for investors when investing in insurers. Interestingly, insurers' stocks are only marginally loaded on the liquidity factor (LIQ).[15]

The average asset size of insurers in our sample is $15.9 billion (not tabulated). Insurers in our sample are on average well capitalized having an average capital to asset ratio of 31.4 percent, with a 10.1 percent standard deviation. During the sample period, the average corporate bond term spread is 1.7 percent and the AAA- vs. BBB- corporate default spread is 1 percent. About 11 percent of the pooled firm-quarter sample is in recession periods. Table 2 indicates that the correlation coefficients between the variables used in the analysis are generally small in magnitude. One notatable finding is that underwriting performance (*Underwr_ROA*) and investment performance (*Inv_ROA*) are not correlated, implying that those two measures are not driven by unobservable common factors (e.g., firm-level efficiency).

To quantify the effect of underwriting profit/(loss) on the cost of capital, we estimate a regression model as follows:

$$Cost\ of\ capital_{i,t} = \beta \times Performance_{i,t-1} + X_{i,t}\delta + \alpha_i + \epsilon_{i,t}, \qquad (6)$$

where the dependent variable is the estimated cost of capital based on one of the three asset pricing models, *i* is the index for insurers and *t* is the index for the quarter. The key independent variables are the performance variables reported at the end of the prior quarter: *Underwr_ROA* and *Inv_ROA.* We include a number of insurer specific control variables that are potentially correlated with an insurer's cost of capital, including firm size, the capital to asset ratio, the percentage of assets in the P/L insurance business. We also include several variables to capture the overall market environment, including whether the economy was in a recession, the term spread, the credit spread, and the dividend yield. Bond market variables are especially relevant for investment environment for insurers (Becker and Ivashina, 2015; Ellul, Jotikasthira, and Lundblad, 2011). To control for industry-wide variation in underwriting profits (see Harrington,

[15] Following the literature on the cost of capital (e.g., Cummins and Phillips, 2005, Berry-Stolze and Xu, 2016), we use the conventional asset pricing models for our baseline results and employ the implied cost of capital models (e.g., Easton, 2004) for additional analyses. A recently developing literature (e.g., Ammar, Eling, and Milidonis, 2018) suggests additional insurance sector factors might better explain insurers' stock returns. Because we are not testing different asset pricing models (and it would be a daunting exercise to try all available models), we follow the conventional approach in this paper.

Niehaus, and Yu, 2013), we include the average combined ratio at the industry level (*Industry combined ratio*). Finally, we include firm fixed effects (α_i) to control for time-invariant, unobservable firm specific characteristics and calendar quarter fixed effects to account for seasonal effects.

4. Empirical analysis

4.1 Are cost of capital estimates from asset pricing models associated with past performance?

Table 3 presents coefficient estimates from the regressions of insurers' cost of capital on the prior quarter's performance results. The coefficient estimates on the *Underwr_ROA* variable are statistically significant at the 5 percent level and equal -0.288, -0.718, and -0.703 when the cost of capital is estimated using the CAPM, Fama-French 3-factor model, and 4-factor model with a liquidity factor, respectively. These estimates indicate that, all else equal, a one-standard-deviation decrease in the *Underwr_ROA* (0.016) leads to an increase in the CAPM cost of capital of 0.0046 (= 0.288 $\times$ 0.016), an increase in the 3-factor cost of capital of 0.0115 (= 0.718 $\times$ 0.016), and an increase in the 4-factor cost of capital of 0.0112 (= 0.703 $\times$ 0.0164). The sample average CAPM cost of capital is 0.069, so the predicted percentage increase in the CAPM cost of capital from a one-standard-deviation decrease in the *Underwr_ROA* is about 7 percent of the average cost of capital. The sample average of 3-factor and 4-factor cost of capital is 0.11, so the predicted percentage increase in the 3-factor and 4-factor cost of capital is about 10 percent of the average cost of capital. These are economically significant impacts. In an untabulated result, we winsorize the cost of capital variables and the *Underwr_ROA* variable. We find that the results are similar to those reported in Table 3. Overall, this empirical finding supports *Hypothesis 1* regarding the impact of underwriting performance on the cost of capital.

In contrast to the significant negative relationship between the cost of capital and underwriting performance, we do not find any statistical evidence that the cost of capital is related to insurer investment performance. Also, in an untabulated analysis, we estimate models in which we replace the *Inv_ROA* variable with its three components. The inferences do not change. Thus, the analysis does not support *Hypothesis 2a* regarding the impact of investment performance on the cost of capital. Instead, the evidence supports *Hypothesis 2b* that the cost of capital and investment performance are not related.

Regarding the control variables, the negative coefficients on *P/L asset ratio* are consistent with prior studies that find that property-casualty insurers have a lower cost of equity capital compared to other business lines of insurers (e.g., Cummins and Phillips, 2005; Barinov, Pottier, and Xu, 2018). The *Default spread* between AAA- and BBB-rated corporate bonds is associated with a higher cost of equity capital, which is consistent with investors requiring additional compensation for risk when the default spread increases. The coefficient estimates on the *Term Spread* variable are positive when the cost of capital is measured using the CAPM, but negative when 3- and 4-factor models are used, which is possibly because the *Term spread* is capturing some variations in the Fama-French risk factors (Petkova 2006; Hahn and Lee 2006).

4.2 Are factor loadings related to underwriting and investment performance?

We also examine how insurers' loadings on risk factors are affected by performance. Table 4 reports the coefficients estimates from regressions of the risk factor loadings on insurers' underwriting and investment performance variables. The same set of control variables are included in these equations, but to conserve space, we only report the coefficients on the main variables of interest. With the exception of the liquidity factor loading (column 8), the coefficient estimate on *Underwr_ROA* is negative in all models and it is statistically significant in five of the models. In contrast, the coefficient on *Inv_ROA* is not significant in any of the models. Overall, these results are consistent with the hypotheses that an increase (decrease) in financial leverage following poor (good) underwriting performance leads to an increase (decrease) in insurers' exposure to undiversifiable risks. Investment performance, however, does not significantly change insurers' exposure to such risks.

Comparing the three models in which the dependent variable is the loading on market risk (columns 1-3), the coefficient on *Underwr_ROA* in the CAPM model is about three times the size of the coefficients in the 3- and 4-factor models. The significant impact of *Underwr_ROA* on the HML and SMB factor loadings and the decreased impact of *Underwr_ROA* on the market risk loading suggests that the CAPM beta is absorbing important variation of insurer's stock return movement which is affected by the value and size factor risk premiums.

Overall, the results in Table 4 corroborate the cost of capital results from Table 3: (1) underwriting performance is negatively related to the cost of capital (*Hypothesis 1*), but (2) investment performance is not related to the cost of capital in a statistically significant way (*Hypothesis 2b*). The results in Table 4 indicate that the negative relation between underwriting performance and the cost of capital is not coming from just one of the risk factor loadings; instead, three of the four factor loadings that we examine are negatively related to underwriting performance. This result is consistent with an increased leverage effect due to poor underwriting performance.

4.3 Does the impact of underwriting performance vary with the type of business?

The empirical analysis is motivated based on the opacity of underwriting in a property-casualty (P/L) insurer. This motivation is less likely to hold for a life insurer for which much of the underwriting is based on well-accepted actuarial "tables." Thus, we expect that the relationship between the cost of capital and underwriting performance is stronger for P/L insurers than for life insurers. Our data are at the group level and therefore include groups with both P/L and life companies. While the previous analyses control for the percentage of the insurer's assets from P/L business (*P/L assets ratio*), it does not examine whether there is an interaction effect with the performance measures.

In Column 1-3 of Table 5, we examine this issue by including in the regression the interaction of *P/L assets ratio* and *Underwr_ROA*. Again, all of the other control variables are included in these models, but we do not report their coefficient estimates for the sake of brevity. The results indicate that the coefficients on *Underwr_ROA* are small and not statistically significant. However, the coefficients on the interaction term are negative and statistically significant, indicating that the impact of underwriting performance on the cost of capital is more pronounced when the firm is more focused on the P/L business. We also include an interaction term of the *P/L assets ratio* and *Inv_ROA* and the coefficient is not statistically significant (not reported in Table 5).

In Columns 4-6, we interact the underwriting performance with a dichotomous variable indicating that the insurer has a *P/L assets ratio* above the median (0.603). In this specification, the coefficients on *Underwr_ROA* are negative but not statistically significant; whereas, the coefficients on the interaction terms are negative and statistically significant. Thus, the effect of underwriting performance on the cost of capital is greater when the insurer is more involved in the P/L business, which is consistent with the conceptual framework and the opacity differences in underwriting in the P/L business versus life business. Again, we include an interaction of the variable indicating that the *P/L assets ratio* is above the median and *Inv_ROA* and the coefficient is not statistically significant (not reported in Table 5).[16]

Taken together, the results suggest that the P/L insurers' underwriting performance provides investors with more relevant information about their opaque underwriting business and thus affects their cost of capital.[17]

4.4 Underwriting performance and the cost of capital during the financial crisis

In an untabulated analysis, we re-estimate the baseline regression models (Equation 6) allowing the coefficient on the underwriting performance variable to vary during the financial crisis, which we define as starting in the third quarter of 2007 and ending in the first quarter of 2009. We find that the impact of underwriting performance on the cost of equity capital during financial crisis is not statistically different from those during non-financial crisis period (not tabulated). This is of interest for two reasons. First, we want to check whether the negative relationship between the cost of capital and underwriting performance is due to what most would consider an unusual time period. Second, we can test whether Chodorow-Reich, Ghent, and Haddad's (2016) asset insulation argument is a possible explanation for our results. They predict and find that asset insulation declines during the financial crisis. Our evidence suggests that the impact of underwriting performance on the cost of capital is not explained by the asset insulation phenomena.

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[16] In a third unreported specification, we used the interaction of the *Underwr_ROA* with a dichotomous variable indicating whether the *P/L assets ratio* is greater than the 75th percentile and omitted observations with a *P/L assets ratio* in the middle quartile. The results indicate that the coefficients on the interaction term are negative and statistically significant, consistent with the results reported in Table 5.

[17] These results are also consistent with Zhang, Cox, and Van Ness (2009) findings that the usual information asymmetry measures such as bid/ask spreads are not related to life insurer assets and liabilities that are classified as opaque.

4.5 Asymmetric relationship between underwriting performance and the cost of capital

In this section, we provide further insights into the relationship between the cost of capital and underwriting performance by investigating whether there is an asymmetric impact of underwriting performance (*Hypothesis 3*). We replace the *Underwr_ROA* with a linear spline with a knot at zero to allow the slope of the relation between the cost of capital and underwriting performance to be asymmetric. Given the results in the previous section that the relationship between underwriting performance and the cost of capital is concentrated in groups that write high levels of P/L business, we report in Table 6 the results for groups with values of *P/L assets ratio* above the median. If instead, we use the entire sample, the evidence is similar, although attenuated (as would be expected given the results above).

Table 6 presents estimated coefficients on the linear splines of the *Underwr_ROA* below and above zero. We report the results of estimating two models for each of the three cost of capital estimates; one uses the actual value *Underwr_ROA* and the other uses the winsorized value of *Underwr_ROA* at the 1 and 99 percentile values. The results indicate that increases in the *Underwr_ROA* above zero are not significantly related to the cost of capital, but that decreases in *Underwr_ROA* below zero are associated with a significant increase (both statistically and economically) in the cost of capital, regardless of the cost of capital model used. These results indicate that the relationship between the cost of capital and underwriting performance is stronger when the insurer reports poor performance compared to when the insurer reports good performance (*Hypothesis 3*).

4.6 Insurer financial stability and the relationship between performance and the cost of capital

Hypothesis 4 posits that the impact of poor performance on the cost of capital is likely to be greater for insurers with less financial stability. To provide evidence of this issue, we report in Table 7 regression results where we interact the *Underwr_ROA* spline variables with a dichotomous variable indicating whether the S&P quality ranking is below B+ and zero otherwise (*Low S&P Rating)*. We do this for the entire sample and for the insurers with *P/L assets ratio* above the median. Consistent with the previous table, the coefficients on the negative part of the *Underwr_ROA* spline are negative and statistically significant in each model and the coefficients on the positive part of the *Underwr_ROA* spline are not statistically significant. The coefficient estimates on the interaction of the negative part of the spline and *Low S&P Rating* are all negative and economically significant; three coefficients are statistically significant. These results indicate that negative performance for financially weak insurers are associated with larger increases in the insurers' cost of equity capital, consistent with market imperfections being important for insurers' cost of capital (*Hypothesis 4*).

4.7 Does analysts coverage substitute for the investor learning channel?

The investor learning channel implies that the impact of underwriting performance on the cost of capital will be mitigated when there is more information available about the value of insurer's liabilities. We use the number of analysts covering the firm as a proxy for the amount of additional information available about insurer liabilities (*Hypothesis 5*). We therefore add to our main regression models interaction terms between insurers' underwriting performance and the number of analysts covering the firm (*Num_Analysts)* as reported in the Institutional Brokers' Estimate System (I/B/E/S) dataset. If the number of analysts is related to the amount of information available about insurer liabilities, then the negative impact of poor underwriting performance on the cost of capital would be mitigated as the number of analysts increase. Consequently, the coefficient on the interaction of poor performance and number of analysts is expected to be positive.

Table 8 presents the results of interacting *Num_Analysts* with each of the components of the spline of *Underwr_ROA*. The first three columns report the results for the entire sample and the last three columns report the results for groups with *P/L assets ratio* greater than the median. For the full sample, the estimated coefficients on the negative part of the *Underwr_ROA* spline are negative and statistically significant in each model consistent with results reported above. Moreover, the coefficients on the interaction terms between *Underwr_ROA* and *Num_Analysts* are positive for the 3 and 4-factor cost of capital. These results indicate that the impact of poor underwriting performance on the cost of capital is less for firms with more analysts coverage, consistent with what the learning channel predicts. However, when we restrict the sample to groups with *P/L assets ratio* greater than the median, we do not find consistent results. Thus, we find mixed evidence regarding Hypothesis 5. A potential explanation for this mixed result is that the information produced by analysts is not informative about the P/L insurers' more opaque underwriting business. In other words, insurer liabilities are opaque to analysts as well.

4.8 Does performance affect the cost of capital aside from the factor loadings?

With the exception of Table 4, the dependent variable in our regressions to this point is an estimated cost of capital, a variable which is determined by the variation in the estimated factor loadings. In Table 4, the dependent variables are the factor loadings. Thus, the preceding analyses suggest that underwriting performance influences the cost of capital through the factor loadings. In this section, we examine whether the cost of capital is influenced by underwriting performance separate from the impact of performance on the factor loadings. To do this, we need a measure of the cost of capital that is not explicitly determined by the factor loadings. We use an implied cost of capital, i.e., the discount rate that sets the present value of all future expected cash flows equal to the current stock price (see below). Intuitively, the implied cost of capital is the required rate of return which makes prospective investors willing to purchase the stock at the current price. We regress the implied cost of capital on past underwriting performance, controlling for the factor loadings from traditional asset pricing models and other controls. In this way, we test whether underwriting performance influences the cost of capital directly, aside from its influence through the factor loadings.

We use four methods from the literature to estimate the implied cost of equity capital; the four models are developed in the following papers:

Easton (2004), which we refer to as the *PEG* model,
Gode and Mohanram (2003), which we refer to as the *GM* model,
Gordon and Gordon (1997), which we refer to as the *GG* model, and
Gebhardt, Lee, and Swaminathan (2001), which we refer to as the *GLS* model.

Each method employs a similar approach, but they differ in assumptions on how they calculate expected future cash flows based on earnings per share and/or dividends per share. A brief explanation of each method is provided in Appendix B. All methodologies are based on using analysts' forecast of earnings (cashflows) and dividend payments from the I/B/E/S dataset, which leads to a reduced number of insurers for analysis compared to the baseline analysis. To rule out the possibility that the price adjustment process is biased by the slow speed adjustment or the leakage of new underwriting disclosures, we use the average daily stock price between one week after the most recent quarterly accounting disclosure and one week prior to the next filing date.[18]

Table 9, Panel A shows summary statistics of the implied cost of capital. The average implied cost of capital ranges from 3.9 percent to 13.6 percent, depending on the method used. The range of estimates is greater than the range of estimates from the asset pricing models (6.9 percent to 11.1 percent). The GLS model yields the lowest average cost of capital estimate out of the four models.[19]

Table 9, Panel B presents coefficient estimates from regressions of the implied cost of equity capital on *Under_ROA*. In these regressions, we include the estimated factor loadings and the other control variables included in the regressions reported earlier. The coefficient estimates on *Under_ROA* in the *PEG*, *GM, and GLS* models are negative and both statistically and economically significant, but the coefficients on *Underwr_ROA* in the *GG* model is not statistically significant and are also small in magnitude.

Overall, the inference we draw from the implied cost of capital analysis is that underwriting performance is associated with the cost of capital above and beyond its impact on the asset pricing factor loadings. This finding is consistent with Froot and Stein (1998) model's implication that poor performance affects investors' view of a firm's leverage, which in turn increases market imperfection costs embedded in the cost of capital.

4.9 Robustness check: Persistency in the cost of capital and endogeneity concerns

To mitigate model misspecification concerns regarding the dynamic nature of the cost of capital, we augment the baseline model with a lagged dependent variable as an additional explanatory variable as follows:

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[18] The results with +/- two weeks periods between two adjacent filing dates are quantitatively and qualitatively same. Results are available upon request.

[19] There are at least three reasons why the GLS method yields relatively lower cost of capital compared to other studies (e.g., Berry-Stolze and Xu, 2016): (1) GLS is a method assuming the mean-reverting dynamics of a firm's long-term ROEs to the industry median of ROEs, (2) lower industry median of ROEs based on the largest 100 P/L insurers in our sample, and (3) a sample period with low rolling-window industry median of ROEs..

$$Cost\ of\ capital_{i,t} = \gamma \times Cost\ of\ capital_{i,t-1} + \beta \times Performance_{i,t-1} + X_{i,t}\delta + \alpha_i + \epsilon_{i,t},\ (7)$$

Because the lagged dependent variable and the insurer fixed effects are mechanically correlated (Nickell, 1981), we apply the system GMM approach to estimate our dynamic model using long lagged dependent variables and their differences as instrumental variables (Arellano and Bover, 1995; Blundell and Bond, 1998).

We also acknowledge that the baseline empirical analysis results could be affected by omitted variable biases. For example, managers can influence the reporting of underwriting results (*Underwr_ROA*) to affect their compensation (Eckles, Halek, Sommer, and Zhang, 2011), tax payments (Weiss, 1985), solvency measures (Gaver and Paterson, 2004), and price regulation (Grace and Leverty, 2010), which could subsequently influence the cost of capital. To reduce endogeneity concerns for *Underwr_ROA*, we use its lagged values as instrumental variables. To the extent that insurers' liability is involved with long-term contracts, *Underwr_ROA* in the prior quarter is likely to be correlated with the *Underwr_ROA* in the current quarter. Consistent with this conjecture, the coefficient from the first-order autoregression of the *Underwr_ROA* is 0.53 (*t-statistic*=36.8). And it is not likely that the long lagged *Underwr_ROA* would directly influence the cost of capital in the current period or through channels other than its impact on recent *Underwr_ROA*. Thus, we assume the *Underwr_ROA* satisfies the exogeneity condition for its lagged variables and use them as instrumental variables.

The Arellano-Bond test for serial correlation in the idiosyncratic error terms of the Equation (7) rejects the null hypothesis of no serial correlation in the first-differenced errors at order one. The test, however, does not reject the null hypothesis at higher orders. Taken together, these results suggest that our moment conditions are valid for the system GMM approach.[20]

Table 10 presents the coefficient estimates from the system GMM regressions of the cost of capital on the *Underwr_ROA*. Each column gives the regression results for a different cost of capital estimate as

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[20] For the dependent and independent variables, we use two lags. Increasing the number of lags does not materially alter our findings (results available upon request). We consider the *Under_ROA* as a predetermined variable, satisfying the exogeneity condition for its lagged variables. We assume all other variables are exogenous and include them in the instrument set in first-differenced form.

the dependent variable. The coefficient estimates on the *Underwr_ROA* are negative and statistically significant across all columns, except for two of the implied cost of capital models (GG and GLS). The economic magnitudes are also comparable to those reported in the earlier regressions. These results indicate that controlling for endogeneity using the instrumental variables does not alter our main finding that bad underwriting performance increases the cost of equity capital for insurers.

5. Conclusion

We investigate the impact of insurers’ underwriting and investment performance on the cost of equity capital. Studying major U.S. property-casualty insurance companies from 1995Q1 to 2016Q3, we find that announcements of poor underwriting performance lead to an increase in the cost of capital. However, announcements of investment performance are not significantly associated with the cost of capital. The difference in the responsiveness of underwriting versus investment performance can be explained by the relative opacity of underwriting operations.

The impact of underwriting performance on the cost of capital is greater when an insurer has underwriting losses and when the company has a low S&P rating. Using implied cost of capital, we also show that underwriting performance is associated with the cost of capital above and beyond the increase in firms’ exposure to traditional risk factors of asset pricing models. These results are consistent with market imperfections being an important channel through which poor performance influences the cost of capital.

Overall, the paper provides evidence of how the opacity of insurers’ liability portfolios can influence insurers' cost of equity capital through market imperfections and investor learning. Our evidence provides rich implications for managers and academics regarding the determinants of cost of capital for financial institutions. The analysis demonstrates that insurers’ role as underwriters, rather than investors, has important implications for understanding the financial aspects of insurers.

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Appendix A: A simple learning model of opaque liabilities

We present a simple model in which investors (and managers) learn about the economic value of an insurer's assets and liabilities from the insurer's underwriting performance. At the beginning of each period, the insurer writes new policies. These policies pay losses that occur over the coming two periods. The policy premium is paid at the beginning of the policy period. At the end of each period, the loss during the period (if any) is paid and the insurer reports the underwriting results. At the beginning of the next period, new policies are written with updated pricing.[21]

Neither investors nor the insurer's managers know the true expected value of claims in a given period. In other words, the portfolio of insurance policies are "opaque" to investors and managers. The model is built on Bayesian learning of investors and managers who update their belief about the expected claims after observing underwriting performance.[22] To focus our discussion on the impact of opaque liability on insurer leverage, we assume the time value of money is zero, administrative costs are zero, and insurers earn a zero return on their investment portfolio.

We consider each period's loss as having a binary stochastic loss event in the amount of $\widetilde{Z_t}$, where $\widetilde{Z_t}$ follows a Bernoulli distribution having an event of a large loss ($\widetilde{Z_t} = L > 0$) with probability θ and low loss ($\widetilde{Z_t} = 0$) with probability $1 - \theta$. The outcomes in successive periods are independent. Since the losses on policies written at time *t* are revealed over two successive time periods, the total loss on policies written at a point in time is the sum of the losses on those policies over the two subsequent time periods. We assume the maximum loss (L) in any period is less than total assets (*A*) to rule out insolvency and focus our discussion on underwriting performance (more on this below).

[21] This is consistent with the way that Warren Buffett describes the insurer liabilities of his firms, which he refers to as "float." Specifically, he writes: "But to think of float as a typical liability is a major mistake. It should instead be viewed as a revolving fund. Daily, we pay old claims and related expenses – a huge $27 billion to more than six million claimants in 2016 – and that reduces float. Just as surely, we each day write new business that will soon generate its own claims, adding to float. See Berkshire Hathaway (2016).

[22] For other studies applying Bayesian investor learning to financial research, see Pastor and Veronesi (2009) and papers cited therein.

The loss size (L) in each period is known, but the probability θ is not known with certainty, which is how we model opacity. Investors and managers believe that θ is a random variable following the *Beta* distribution, $Beta\ (\alpha, \beta)$, where the parameters α and β determine the shape of the distribution (α and β are positive).[23] Thus, at the start of the process, investors' and managers' expected value of θ is $E_0(\theta) = \frac{\alpha}{\alpha+\beta}$, where $E_t(.)$ is the expectation operator given information as of time t. Since losses potentially occur over two periods, the total losses on policies written in any period equal either 2L, L, or 0. The expected value of losses on policies written at the beginning of period t therefore equals

$$E_t[\ 2\theta(1-\theta)L + \theta^2 2L\ ] = 2L\ E_t(\theta)\ .$$

The policies written at time therefore have an expected loss equal to $2L\ \frac{\alpha}{\alpha+\beta}$.

Assume that insurers initially sell policies at a fair premium plus a percentage markup equal to λ. Then the premium revenue at the beginning of the first period equals $\frac{\alpha}{\alpha+\beta}\ 2L(1+\lambda)$. Also assume that the insurer has initial contributed capital equal to C_0, which implies that the insurer's assets after writing the first set of policies is $C_0 + \frac{\alpha}{\alpha+\beta} 2L(1+\lambda)$. To ensure that solvency is not a concern, assets have to exceed potential costs on the policies that have been written, which implies that $C_0 + \frac{\alpha}{\alpha+\beta} 2L(1+\lambda) > 2L$, or equivalently, $C_0 > \frac{\beta-\lambda\alpha}{\alpha+\beta}\ 2L$. The initial level of capital (assets minus liabilities) equals

$$C_0 + \frac{\lambda\alpha}{\alpha+\beta} 2L \quad .$$

The top row of Table A1 summarizes the initial balance sheet of the insurers.

Now suppose that a large loss event occurs during the first period, i.e., $\widetilde{Z_1} = L$. Reported underwriting profits would equal earned premiums minus the loss incurred during the first period, which equals

$$\frac{\alpha}{\alpha+\beta}\ L(1+\lambda) - L = \frac{\lambda\alpha}{\alpha+\beta} L\ -\ \frac{\beta}{\alpha+\beta} L\ \ .$$

[23] We consider the *Beta* distribution as the prior because it is a conjugate prior of Bernoulli distribution and the posterior distribution is also a *Beta* distribution which allows us to derive the expected loss in a simple way.

Provided the size of the markup (λ) is small enough, underwriting profits would be negative. Regardless of the markup, capital is depleted (relative to the capital at time 0) by the unexpected loss $\frac{\beta}{\alpha+\beta}$ L.[24] This is the first channel discussed in the text – an unexpected loss decreases the insurer's capital and therefore increases its financial leverage. The second row in Table A1 summarizes this effect.

After observing the poor underwriting performance in the first period, the managers and investors update their belief about the probability of a large loss event (θ) for the next period using Bayes' rule. As is well known with the Bernoulli distribution and the *Beta* prior, the posterior for the loss probability (θ) follows the *Beta* distribution with an updated parameter values, $Beta\ (\alpha+1, \beta)$.[25] The expected value of θ is now $E_1(\theta|Z_1 = L) = \frac{\alpha+1}{\alpha+\beta+1}$. Thus, the insurer's updated economic liability at *t*=1 on policies written at time 0 equals $\frac{\alpha+1}{\alpha+\beta+1}$ L. The policies have already been sold and so raising prices on these policies is not possible. The insurer's economic capital (assets minus liabilities) would therefore equal

$$C_0 + \frac{\alpha}{\alpha+\beta}\, 2L(1+\lambda) - L - \frac{\alpha+1}{\alpha+\beta+1}L = C_0 + \frac{\lambda\alpha}{\alpha+\beta}\, 2L - \frac{\beta}{(\alpha+\beta)}L \;-\; \frac{\beta}{(\alpha+\beta)(\alpha+\beta+1)}L\ .$$

The marginal effect on capital of updating expectations is $\frac{-\beta}{(\alpha+\beta)(\alpha+\beta+1)}L$ This is the second channel discussed in the text and is summarized in the third row of Table A1.

Policies written at the beginning of the second period will presumably reflect, at least to some extent, the updated expectations of claims in the future. To the extent that insurers are slow to incorporate the updated expectations and/or that policyholder demand for policies declines as a result of capital reductions by insurers, the markup on new policies, which we denote by λ', could be less than on previously written policies. If λ' ≤ 0, then the new policies are sold at premium less than the expected loss and capital is further deleted. This is the third channel discussed in the text and is summarized in the last row of Table A1.[26]

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[24] If some of the claims incurred are not yet paid, then assets would decline by the amount paid and liabilities would increase by the amount of unpaid claims.
[25] See e.g., Hogg, Sloan, and Hassan (2012).
[26] To continue to ensure solvency after writing the second period's policies, the insurer would need to have assets of at least 3L, the maximum that losses could be on the policies already written. Let C_1 equal the contributed capital at

If a large loss event does not occur during the first period ($\widetilde{Z_1} = 0$), investors and managers also update their belief about the probability distribution of θ. The posterior distribution is $Beta(\alpha, \beta + 1)$, and so the expected value of θ is $E_1(\theta|L_1 = 0) = \frac{\alpha}{\alpha+\beta+1}$. Using the same logic as above, one can show that the insurer's economic capital increases, which lowers the firm's financial leverage.

time 1. Then, the insurer's assets after writing policies at the beginning of the second period equal $C_0 + \frac{\alpha}{\alpha+\beta}2L - L + 2\lambda' L\frac{\alpha+1}{\alpha+\beta+1} + C_1$.

Table A1: The balance sheet implications of the learning model

This table summarizes the balance sheet implications of the model by highlighting the three channels (rows labeled 1-3) through which underwriting performance influences an insurer's capital.

		Marginal Change in Capital relative to previous row	**Brief Explanation**
0.	**t = 0** Assets = $C_0 + \frac{\alpha}{\alpha+\beta} 2L(1+\lambda)$ Liab = $\frac{\alpha}{\alpha+\beta} 2L$ Capital = $C_0 + \frac{\alpha}{\alpha+\beta} 2L\lambda$		Initial level of capital
1.	**t = 1, Z = L before updating** Assets = $C_0 + \frac{\alpha}{\alpha+\beta} 2L(1+\lambda) - L$ Liab = $\frac{\alpha}{\alpha+\beta} L$ Capital = $C_0 + \frac{\alpha}{\alpha+\beta} 2L\lambda - \frac{\beta}{\alpha+\beta} L$	$- \frac{\beta}{\alpha+\beta} L$	Unexpected claims
2.	**t = 1, Z = L, after updating, before writing new policies** Assets = $C_0 + \frac{\alpha}{\alpha+\beta} 2L(1+\lambda) - L$ Liab = $\frac{\alpha+1}{\alpha+\beta+1} L$ Capital = $C_0 + \frac{\alpha}{\alpha+\beta} 2L\lambda - \frac{\beta}{\alpha+\beta} L - \frac{\beta}{(\alpha+\beta+1)(\alpha+\beta)} L$	$- \frac{\beta}{(\alpha+\beta+1)(\alpha+\beta)} L$	Change in expected claims on past policies
3.	**t = 1, Z = L, after updating, after writing new policies** Assets = $C_0 + \frac{\alpha}{\alpha+\beta} 2L(1+\lambda) - L + \frac{\alpha+1}{\alpha+\beta+1} 2L(1+\lambda')$ Liab = $\frac{\alpha+1}{\alpha+\beta+1} L + \frac{\alpha+1}{\alpha+\beta+1} 2L$ Capital = $C_0 - \frac{\beta}{\alpha+\beta} L - \frac{\beta}{(\alpha+\beta+1)(\alpha+\beta)} L$ $+ \lambda' \frac{\alpha+1}{\alpha+\beta+1} 2L$	$\lambda' \frac{\alpha+1}{\alpha+\beta+1} 2L$	Pricing less than expected costs on new policies

Appendix B: Variable descriptions

Variable	Description
"Underwriting Results"	
Underwr_ROA	Underwriting profits divided by admitted assets, where profits equal the sum of the loss ratio and expense ratio multiplied by earned premiums
Loss ratio	A measure of property and casualty loss payment results defined as the ratio of losses and loss adjustment expenses to earned premiums; a higher value indicates lower underwriting profit due to loss payments.
Expense ratio	A measure of property and casualty underwriting expenses results defined as the ratio of other underwriting expenses to written premiums; a higher value indicates lower underwriting profit due to underwriting expenses.
"Investment Results"	
Inv_ROA	The sum of investment income, realized capital gains, and unrealized capital gains
Investment income	The ratio of net investment income, primarily dividends from stocks and interest on bonds, to total admitted assets.
Realized capital gains	The ratio of realized capital gains to total admitted assets.
Unrealized capital gains	The ratio of unrealized capital gains to total admitted assets.
"Risk Factor Loadings"	
Beta (MKT): CAPM	Loading on the market risk for each firm estimated by the CAPM model using daily stock returns from a filing date to a next filing date.
Beta (MKT): 3-factor	Loading on the market risk for each firm estimated by the Fama-French 3-factor model using daily stock returns from a filing date to a next filing date.
Beta (MKT): 4-factor	Loading on the market risk for each firm estimated by the Fama-French 3-factor and Pastor-Stambaugh liquidity factor model using daily stock returns from a filing date to a next filing date.
Beta (HML): 3-factor	Loading on the HML risk factor for each firm estimated by the Fama-French 3-factor model using daily stock returns from a filing date to a next filing date.

Beta (HML): 4-factor	Loading on the HML factor for each firm estimated by the Fama-French 3-factor and Pastor-Stambaugh liquidity factor model using daily stock returns from a filing date to a next filing date.
Beta (SMB): 3-factor	Loading on the SMB risk factor for each firm estimated by the Fama-French 3-factor model using daily stock returns from a filing date to a next filing date.
Beta (SMB): 4-factor	Loading on the SMB factor for each firm estimated by the Fama-French 3-factor and Pastor-Stambaugh liquidity factor model using daily stock returns from a filing date to a next filing date.
Beta (LIQ):4-factor	Loading on the liquidity factor for each firm estimated by the Fama-French 3-factor and Pastor-Stambaugh liquidity factor model using daily stock returns from a filing date to a next filing date.

"Cost of capital"

Cost of capital (CAPM)	Cost of equity capital for each firm based on the CAPM: risk-free rate + *Beta (MKT): CAPM* $\times$ expected market risk premium.
Cost of capital (3-Factor)	Cost of equity capital for each firm based on the Fama-French 3-factor model: risk-free rate + *Beta (MKT): 3-factor* $\times$ expected market risk premium + *Beta (HML): 3-factor* $\times$ avg. return of HML factor + *Beta (SMB): 3-factor* $\times$ avg. return of SMB factor
Cost of capital (4-Factor)	Cost of equity capital for each firm based on the Fama-French 3-factor model with the Pastor-Stambaugh liquidity factor: risk-free rate + *Beta (MKT): 4-factor* $\times$ expected market risk premium + *Beta (HML): 4-factor* $\times$ avg. return of HML factor + *Beta (SMB): 4-factor* $\times$ avg. return of SMB factor + *Beta (LIQ): 4-factor* $\times$ avg. return of liquidity factor.
Cost of capital (PEG)	$P_t = (FEPS_2 + PEG \times FDPS_2 - FEPS_1)/PEG^2$, where P_t is the price per share of common stock in year t, and PEG is the implied cost of equity capital. $FEPS_1$ and $FEPS_2$ are equal to the 1- and 2-year-ahead consensus EPS forecasts. $FDPS_2$ is the expected dividend per share 2-year ahead calculated as $\text{FEPS}_2 \times \text{k}$, where k is the current dividend payout ratio, defined as the ratio of the actual dividends from the most recent fiscal year divided by earnings over the same time period for firms with positive earnings, or divided by 0.012 total assets for life insurers with negative earnings

Cost of capital (GM)

$P_t = \frac{FEPS_1}{GM} + \frac{FEPS_2 - FEPS_1 - GM(FEPS_1 - FDPS_1)}{GM(GM - g_p)}$, where P_t is the price per share of common stock in year t, and GM is the implied cost of equity capital. $FEPS_1$ and $FEPS_2$ are equal to the 1- and 2-year-ahead consensus EPS forecasts. $FDPS_{t+1}$ is the expected dividend per share calculated as FEPS×k, where k is the current dividend payout ratio, defined as the ratio of the actual dividends from the most recent fiscal year divided by earnings over the same time period for firms with positive earnings, or divided by 0.012 total assets for life insurers with negative earnings. g_p is the nominal long-term growth rate and is set equal to the 10-year Treasury Bond rates minus 3% for the period from 1996 to 2007 and minus the 10-year Treasury Inflation Protected Securities (TIPS) rates for the period from 2008 to 2012.

Cost of capital (GG)

$P_t = \sum_{i=1}^{5} \frac{FDPS_{t+i}}{(1+gg)^i} + \frac{FEPS_{t+e}(1+LTG)}{gg(1+gg)^5}$, P_t is the price per share of common stock in year t, and gg is the implied cost of equity capital. $FDPS_{t+i}$ is the expected dividend per share calculated as $FEPS_{t+i} \times k$, where, k is the current dividend payout ratio, defined as the ratio of the actual dividends from the most recent fiscal year divided by earnings over the same time period for firms with positive earnings, or divided by 0.012 ×total assets for life insurers with negative earnings. $FEPS_{t+5}$ is the 5-year-ahead expected EPS, which are approximated by the 5-year-ahead consensus EPS forecast by analysts when available, and $FEPS_{t+i} = FEPS_t \times (1 + LTG)$ if $FEPS_t \geq 0$. when not available, where LTG is the long-term growth EPS forecast.

Cost of Capital (GLS)

$P_t = B_t + \sum_{i=1}^{11} \frac{FROE_{t+i} - r_{GLS}}{(1+r_{GLS})^i} B_{t+i-1} + \frac{FROE_{t+12} - r_{GLS}}{(1+r_{GLS})^{11}} B_{t+11}$, where P_t is the price per share of common stock in year t, r_{GLS} is the implied cost of equity capital, B_t is the book equity value per share, $(FROE_{t+i} - r_{GLS}) \times B_{t+11}$ is the residual income in year t+1, and $FROE_{t+i}$ is the expected return on book equity. Book equity is determined based on clean surplus accounting, that is, B_{t+1}=B_t+$FEPS_{t+i}$ ×(1-k), where, k is the current dividend payout ratio defined as the ratio of the actual dividends from the most recent fiscal year divided by earnings over the same time period for firms with positive earnings, or divided by 0.034 total assets for non-life insurers with negative earnings. $FROE_{t+i}$ is computed as $FEPS_{t+i}$/ Bt+i-1. $FEPS_{t+i}$ is the I/B/E/S mean forecasted EPS for year t+I. If the mean forecasted EPS is not available, $FEPS_{t+i}$ = $FEPS_{t-1}$(1+ Ltg). Ltg is the long-term growth rate from the I/B/E/S.

“Insurer Characteristics”

LogAssets	The logarithm of total admitted assets in millions (USD).
Capital ratio	The ratio of total admitted asset minus total liabilities divided by total admitted assets. Liabilities include all borrowing and policy coverages.
P/L assets ratio	The ratio of property and casualty line assets to whole group assets.
S&P Rating	Equals one if the S&P Quality Rating is below B+ and zero otherwise.

Num_Analysts	The number of financial analysts covering an insurer reported in the Institutional Brokers' Estimate System (I/B/E/S) dataset.
"Macro Variables"	
Industry combined ratio	The average combined ratio of all property/casualty insurers.
Term spread	The average yield spread between 3-month and 10-year Treasury constant maturity rate from a filing date to a next filing date.
Default spread	The average yield spread between Moody's BBB and AAA corporate bonds from a filing date to a next filing date.
Dividend yield	The average aggregate dividend yield from a filing date to a next a next filing date.
NBER recession	A dummy variable that equals one if the time is in 2001Q3- 2001Q4 or 2007Q4-2009Q2, and zero otherwise.

Table 1: Descriptive statistics for the sample

This table presents summary statistics for our main variables. The sample includes 92 property and casualty insurers from 1995Q1 through 2016Q3. Observations are on a firm-year/quarter level. *Underwr_ROA* is the sum of loss ratio and the expense ratio multiplied by the ratio of earned premiums to admitted assets. *Inv_ROA* is the sum of the return on assets from investment income, unrealized capital gains, and realized capital gains. *Beta (MKT): CAPM/3-factor/4-factor* are loadings on the market risk for each firm estimated by CAPM, Fama-French 3-factor model, and a 4-factor model with a Pastor-Stambaugh liquidity factor, respectively. *Beta (HML): 3-factor/4-factor* are loadings on the HML factor for each firm estimated by Fama-French 3-factor and a 4-factor model with a Pastor-Stambaugh liquidity factor. *Beta (SMB): 3-factor/4-factor* are loadings on the SMB factor for each firm estimated by Fama-French 3-factor and a 4-factor model with a Pastor-Stambaugh liquidity factor. All factor loadings are estimated using daily stock return data after a filing date to a next filing date. Factor loadings are estimated with a sum-beta approach (Scholes and Williams, 1977; Dimson, 1979; Cummins and Phillips, 2005). All other variables are defined in the Appendix B.

	N	Mean	StDev	10th Percentile	Median	90% Percentile
Underwr_ROA	3725	0.001	0.016	-0.013	0.002	0.014
Loss ratio	3725	0.710	0.336	0.491	0.691	0.874
Expense ratio	3725	0.288	0.109	0.199	0.290	0.364
Inv_ROA	3725	0.011	0.015	0.001	0.010	0.022
Investment income	3725	0.009	0.004	0.005	0.009	0.014
Realized capital gains	3725	0.001	0.009	-0.001	0.001	0.005
Unrealized cap gains	3725	0.000	0.015	-0.009	0.000	0.009
Cost of capital (CAPM)	3725	0.069	0.027	0.044	0.065	0.094
Cost of capital (3-factor)	3725	0.110	0.096	0.031	0.097	0.207
Cost of capital (4-factor)	3607	0.111	0.098	0.030	0.098	0.208
Beta (MKT):CAPM	3725	0.861	0.676	0.235	0.774	1.486
Beta (MKT):3-factor	3725	0.900	0.723	0.246	0.837	1.657
Beta (MKT):4-factor	3607	0.907	0.730	0.246	0.835	1.653
Beta (HML):3-factor	3725	0.629	1.362	-0.472	0.489	1.856
Beta (HML):4-factor	3607	0.644	1.407	-0.487	0.504	1.916
Beta (SMB):3-factor	3725	0.227	0.936	-0.691	0.146	1.249
Beta (SMB):4-factor	3607	0.226	0.972	-0.721	0.146	1.255
Beta (LIQ):4-factor	3607	0.000	0.169	-0.065	-0.001	0.063
LogAssets	3725	8.724	1.269	7.243	8.478	10.634
Capital ratio	3725	0.314	0.101	0.204	0.297	0.446
P/L assets ratio	3725	0.577	0.302	0.136	0.603	1.000
Num_Analysts	3725	6.297	5.898	0.000	4.667	15.667
Industry combined ratio	3725	1.023	0.067	0.937	1.019	1.121
Term Spread	3725	0.017	0.011	0.002	0.017	0.033
Default spread	3725	0.010	0.004	0.006	0.009	0.014
Agg. Dividend yield	3725	0.018	0.040	0.000	0.005	0.050
NBER recession	3725	0.110	0.313	0.000	0.000	1.000

Table 2: Correlation matrix

This table presents Pearson correlation coefficients across our main independent and dependent variables. The sample includes 92 property and casualty insurers from 1995Q1 through 2016Q3. The observations are on a firm-quarter level. Correlations that are significant at the 5% level are shown in bold

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) Underwr_ROA	1.00																
(2) Loss ratio	**-0.78**	1.00															
(3) Expense ratio	**-0.07**	**-0.25**	1.00														
(4) Cost of capital (CAPM)	**-0.16**	**0.32**	**-0.15**	1.00													
(5) Cost of capital (3-factor)	**-0.14**	**0.20**	**-0.07**	**0.45**	1.00												
(6) Cost of capital (4-factor)	**-0.14**	**0.20**	**-0.09**	**0.44**	**0.97**	1.00											
(7) Inv_ROA	0.01	**-0.07**	0.01	**-0.07**	0.01	0.00	1.00										
(8) Investment income	-0.03	**-0.05**	0.00	**-0.08**	0.03	0.02	**0.20**	1.00									
(9) Realized capital gains	-0.02	-0.03	0.01	**-0.05**	-0.03	-0.03	**0.25**	**-0.05**	1.00								
(10) Unrealized capital gains	0.03	**-0.04**	0.00	-0.02	0.02	0.02	**0.78**	**-0.06**	**-0.35**	1.00							
(11) Size	-0.02	**0.05**	**-0.13**	**0.06**	**-0.07**	**-0.07**	0.02	0.00	0.00	0.02	1.00						
(12) Capital ratio	**0.21**	**-0.17**	**-0.09**	**-0.17**	**-0.10**	**-0.11**	**0.11**	0.03	**0.10**	**0.04**	0.02	1.00					
(13) P/L assets ratio	0.02	-0.03	**0.06**	**-0.11**	0.01	0.02	0.01	-0.01	0.00	0.01	**-0.14**	**0.05**	1.00				
(14) Ind. combined ratio	**-0.29**	**0.17**	0.01	**-0.10**	**0.04**	**0.04**	0.01	**0.18**	0.00	**-0.04**	**-0.08**	**-0.04**	0.00	1.00			
(15) Term Spread	**-0.07**	**0.09**	-0.03	**0.13**	**-0.07**	**-0.07**	**-0.11**	**-0.22**	**-0.09**	0.01	**0.08**	**-0.05**	**-0.04**	**0.08**	1.00		
(16) Default Spread	**-0.04**	**0.11**	**-0.06**	**0.21**	**0.03**	**0.04**	**-0.27**	**-0.12**	**-0.19**	**-0.12**	**0.08**	**-0.05**	-0.03	**0.13**	**0.36**	1.00	
(17) Dividend Yield	**0.08**	**-0.05**	0.03	-0.01	0.00	0.00	**0.05**	**0.15**	0.02	-0.01	0.03	**-0.08**	**-0.05**	0.01	**-0.05**	-0.02	1.00
(18) NBER recession	**-0.07**	**0.13**	**-0.07**	**0.18**	**0.05**	**0.04**	**-0.18**	0.00	**-0.17**	**-0.07**	0.03	**-0.04**	-0.02	**0.22**	**0.29**	**0.67**	0.01

Table 3: Underwriting performance and the cost of capital

This table presents coefficient estimates from OLS regressions of *Cost of capital* on quarterly underwriting and investment performance results (*Underwr_ROA, Inv_ROA*). The sample includes 92 property and casualty insurers from 1995Q1 through 2016Q3. *Cost of capital (CAPM)* is the cost of capital estimate based on the CAPM using daily stock price returns after quarterly underwriting cost/(profit) is filed. *Cost of capital (3-Factor)* is the cost of capital estimate based on the Fama-French 3 factor model (Fama and French 1992). *Cost of capital (4-Factor)* is similarly defined as *Cost of capital (3-Factor)* with an additional liquidity factor (Pastor and Stambaugh 2003). Factor loadings are estimated with a sum-beta approach (Scholes and Williams 1977; Dimson 1979; Cummins and Phillips 2005). *Underwr_ROA* is the sum of loss ratio and expense ratio multiplied by the earned premium to admitted asset ratio. *Inv_ROA* is the sum of the return on assets from investment income, unrealized capital gains, and realized capital gains. All other variables are as described in Appendix B. *t*-statistics with standard errors adjusted for heteroskedasticity and clustered at a firm level are reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

	(1) CAPM	(2) 3-Factor	(3) 4-Factor
Underwr_ROA	-0.288**	-0.718**	-0.703**
	(-2.169)	(-2.402)	(-2.552)
Inv_ROA	0.012	0.127	0.055
	(0.419)	(1.103)	(0.427)
LogAssets	0.008***	0.005	0.006
	(3.454)	(0.651)	(0.750)
Capital ratio	-0.010	0.021	0.013
	(-0.626)	(0.471)	(0.279)
P/L assets ratio	-0.017	-0.058*	-0.057*
	(-1.614)	(-1.884)	(-1.895)
Ind combined ratio	-0.072***	-0.030	-0.025
	(-4.908)	(-0.809)	(-0.664)
Term spread	0.107***	-0.741***	-0.776***
	(2.655)	(-4.117)	(-4.051)
Default spread	0.759***	1.177**	1.489***
	(3.949)	(2.332)	(2.671)
Dividend yield	-0.010	-0.009	-0.006
	(-1.261)	(-0.242)	(-0.164)
NBER recession	0.008***	0.012	0.007
	(3.876)	(1.565)	(0.964)
Observations	3,725	3,725	3,606
R-squared	0.373	0.173	0.168

Table 4: Underwriting performance and risk factor loadings

This table presents coefficient estimates from OLS regressions of factor loadings on quarterly underwriting and investment performance results. The sample includes 92 property and casualty insurers from 1995Q1 through 2016Q3. *Beta (MKT): CAPM/3-factor/4-factor* are loadings of market risk for each firm estimated by the CAPM, the Fama-French 3-factor model, and the 4-factor model with a Pastor-Stambaugh liquidity factor, respectively. *Beta (HML): 3-factor/4-factor* are loadings on the HML factor for each firm estimated by the Fama-French 3-factor and a 4-factor model with a Pastor-Stambaugh liquidity factor. *Beta (SMB): 3-factor/4-factor* are loadings on the SMB factor for each firm estimated by the Fama-French 3-factor and the 4-factor model with a Pastor-Stambaugh liquidity factor. All factor loadings are estimated using daily stock return data after a filing date to a next filing date. Factor loadings are estimated with a sum-beta approach (Scholes and Williams 1977; Dimson 1979; Cummins and Phillips 2005). *Underwr_ROA* is the sum of loss ratio and expense ratio multiplied by the earned premium to admitted asset ratio. *Inv_ROA* is the sum of the return on assets from investment income, unrealized capital gains, and realized capital gains. *Controls* represent all other control variables presented in Table 3. All other variables are as described in Appendix B. *t*-statistics with standard errors adjusted for heteroskedasticity and clustered at a firm level are reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

	Beta (MKT)			*Beta (HML)*		*Beta (SMB)*		*Beta (LIQ)*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CAPM	3-Factor	4-Factor	3-Factor	4-Factor	3-Factor	4-Factor	4-Factor
Underwr_ROA	-7.163**	-2.751	-2.714	-7.534**	-6.976**	-6.726**	-6.943***	0.402
	(-2.169)	(-1.276)	(-1.265)	(-2.045)	(-2.043)	(-2.509)	(-3.167)	(0.636)
Inv_ROA	0.302	1.880	2.111	0.009	-0.685	1.546	0.001	-0.258
	(0.419)	(0.848)	(0.898)	(0.004)	(-0.246)	(1.063)	(0.001)	(-0.302)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
N	3,725	3,725	3,606	3,725	3,606	3,725	3,606	3,606
R-squared	0.373	0.188	0.179	0.112	0.112	0.203	0.197	0.027

Table 5: Interaction of underwriting performance with the percentage of assets devoted to property-casualty business

This table presents coefficient estimates from OLS regressions of *Cost of capital* on an interaction term of quarterly underwriting (*Underwr_ROA*) and investment performance (*Inv_ROA*) results and property-casualty asset ratio. The sample includes 92 property and casualty insurers from 1995Q1 through 2016Q3. *Cost of capital (CAPM)* is the cost of capital estimate based on the CAPM using daily stock price returns after quarterly underwriting cost/(profit) is filed. *Cost of capital (3-Factor)* is the cost of capital estimate based on the Fama-French 3 factor model (Fama and French 1992). *Cost of capital (4-Factor)* is similarly defined as *Cost of capital (3-Factor)* with an additional liquidity factor (Pastor and Stambaugh 2003). Factor loadings are estimated with a sum-beta approach (Scholes and Williams 1977; Dimson 1979; Cummins and Phillips 2005). *Underwr_ROA* is the sum of loss ratio and expense ratio multiplied by the earned premium to admitted asset ratio. *Controls* represent all other control variables presented in Table 3. *t*-statistics with standard errors adjusted for heteroskedasticity and clustered at a firm level are reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

	(1) CAPM	(2) 3-Factor	(3) 4-Factor	(4) CAPM	(5) 3-Factor	(6) 4-Factor
Underwr_ROA	0.076 (1.050)	0.192 (0.673)	0.115 (0.390)	-0.062 (-1.153)	-0.276 (-1.022)	-0.290 (-1.107)
Underwr_ROA × *P/L assets ratio*	-0.636*** (-3.096)	-1.586*** (-3.209)	-1.411*** (-2.826)			
P/L assets ratio	-0.014 (-1.394)	-0.057* (-1.831)	-0.055* (-1.822)			
Underwr_ROA × *(P/L assets ratio>Med)*				-0.434*** (-2.675)	-0.852** (-2.094)	-0.796** (-2.022)
(P/L asset ratio>Med)				-0.000 (-0.040)	-0.021** (-2.506)	-0.016* (-1.174)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
R-squared	0.387	0.180	0.173	0.385	0.177	0.170
N	3,725	3,725	3,606	3,725	3,725	3,606

Table 6: Nonlinearity of the impact of underwriting performance on the cost of capital

This table presents coefficient estimates from regressions of *Cost of capital* on linear splines of quarterly underwriting performance (*Underwr_ROA*) with a knot at zero. The original sample includes 92 property and casualty insurers from 1995Q1 through 2016Q3. The sample used in the table consists of those observations that have above the median value for the ratio of P/L assets to total assets (*P/L assets ratio*). *Cost of capital (CAPM)* is the cost of capital estimate based on the CAPM using daily stock price returns after quarterly underwriting cost/(profit) is filed. *Cost of capital (3-Factor)* is the cost of capital estimate based on the Fama-French 3 factor model (Fama and French 1992). *Cost of capital (4-Factor)* is similarly defined as *Cost of capital (3-Factor)* with an additional liquidity factor (Pastor and Stambaugh 2003). Factor loadings are estimated with a sum-beta approach (Scholes and Williams 1977; Dimson 1979; Cummins and Phillips 2005). *Underwr_ROA* is the sum of loss ratio and expense ratio multiplied by the earned premium to admitted asset ratio (winsorized at the one and 99 percentile values in columns 2,4, and 6). *Insurer variables* include *LogAssets*, *Capital ratio*, and *P/L asset ratio*. *Macro variables* include *Industry combined ratio*, *Term Spread*, *Default spread*, *Dividend yield*, and *NBER recession*. All variables are as described in Appendix B. *t*-statistics with standard errors adjusted for heteroskedasticity and clustered at a firm level are reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

	Cost of capital (CAPM)		*Cost of capital (3-Factor)*		*Cost of capital (4-Factor)*	
	(1)	(2)	(3)	(4)	(5)	(6)
Underwr_ROA **< *0***	-0.644***	-0.839***	-1.163***	-1.718***	-1.091***	-1.693***
	(-4.496)	(-3.231)	(-3.173)	(-3.367)	(-3.160)	(-3.358)
Underwr_ROA > 0	-0.144	-0.229	-0.904	-0.870	-0.907	-0.919
	(-0.570)	(-0.885)	(-1.299)	(-1.204)	(-1.408)	(-1.318)
Underwr_ROA winsorized	NO	YES	NO	YES	NO	YES
Insurer & *Macro* variables	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
R-squared	0.400	0.401	0.165	0.168	0.156	0.161
N	1,859	1,859	1,859	1,859	1,800	1,800

Table 7: Cross-sectional heterogeneity of the underwriting risk and the cost of capital

This table presents coefficient estimates from OLS regressions of *Cost of capital* on interaction terms of financial strength (*Low S&P Rating*) and quarterly underwriting performance results. The sample includes 92 property and casualty insurers from 1995Q1 through 2016Q3. *Cost of capital (CAPM)* is the cost of capital estimate based on the CAPM using daily stock price returns after quarterly underwriting cost/(profit) is filed. *Cost of capital (3-Factor)* is the cost of capital estimate based on the Fama-French 3 factor model (Fama and French 1992). *Cost of capital (4-Factor)* is similarly defined as *Cost of capital (3-Factor)* with an additional liquidity factor (Pastor and Stambaugh 2003). Factor loadings are estimated with a sum-beta approach (Scholes and Williams 1977; Dimson 1979; Cummins and Phillips 2005). *Low S&P Rating* equals one if S&P Quality Ranking is below B+, and zero otherwise. *Underwr_ROA* is the sum of loss ratio and expense ratio multiplied by the earned premium to admitted asset ratio *Controls* represent all other control variables presented in Table 3. *t*-statistics with standard errors adjusted for heteroskedasticity and clustered at the firm level are reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

Sample	Full sample			*P/L assets ratio*>Median		
	(1)	(2)	(3)	(4)	(5)	(6)
	CAPM	3-Factor	4-Factor	CAPM	3-Factor	4-Factor
Underwr_ROA < ***0***	-0.280**	-0.928***	-0.894***	-0.458***	-0.980*	-0.896*
	(-2.525)	(-2.769)	(-2.819)	(-3.036)	(-1.826)	(-1.807)
Underwr_ROA > ***0***	-0.096	-0.054	0.015	-0.182	-0.954	-0.758
	(-0.641)	(-0.084)	(0.026)	(-0.891)	(-1.140)	(-1.054)
Underwr_ROA < ***0*** ×	-0.703***	-0.778	-0.899*	-0.664**	-0.654	-0.901
Low S&P Rating	(-3.393)	(-1.531)	(-1.864)	(-2.452)	(-0.790)	(-1.154)
Underwr_ROA > ***0*** ×	0.103	-0.864	-1.346	-0.101	-1.375	-1.606
Low S&P Rating	(0.172)	(-0.594)	(-0.899)	(-0.237)	(-1.310)	(-1.438)
Low S&P Rating	0.007*	0.041**	0.045**	0.008	0.049*	0.050*
	(1.879)	(2.133)	(2.393)	(1.381)	(1.982)	(1.919)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
R-squared	0.445	0.247	0.242	0.490	0.263	0.256
N	2,834	2,834	2,749	1,219	1,219	1,188

Table 8: Underwriting performance and the cost of capital conditional on information availability

This table presents coefficient estimates from OLS regressions of *Cost of capital* on interaction terms of analysts coverage (*Num_Analysts*) and quarterly underwriting performance results. The sample includes 92 property and casualty insurers from 1995Q1 through 2016Q3. *Cost of capital (CAPM)* is the cost of capital estimate based on the CAPM using daily stock price returns after quarterly underwriting cost/(profit) is filed. *Cost of capital (3-Factor)* is the cost of capital estimate based on the Fama-French 3 factor model (Fama and French 1992). *Cost of capital (4-Factor)* is similarly defined as *Cost of capital (3-Factor)* with an additional liquidity factor (Pastor and Stambaugh 2003). Factor loadings are estimated with a sum-beta approach (Scholes and Williams 1977; Dimson 1979; Cummins and Phillips 2005). *Underwr_ROA* is the sum of loss ratio and expense ratio multiplied by the earned premium to admitted asset ratio. *Num_Analysts* is the number of financial analysts covering an insurer reported in the Institutional Brokers' Estimate System (I/B/E/S) dataset. *Controls* represent all other control variables presented in Table 3. *t*-statistics with standard errors adjusted for heteroskedasticity and clustered at the firm level are reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

Sample	Full sample			*P/L assets ratio*>Median		
	(1)	(2)	(3)	(4)	(5)	(6)
	CAPM	3-Factor	4-Factor	CAPM	3-Factor	4-Factor
Underwr_ROA **< *0***	-0.362**	-1.519***	-1.468***	-0.483	-1.169	-1.150
	(-2.154)	(-4.014)	(-3.944)	(-1.429)	(-1.623)	(-1.509)
Underwr_ROA **> *0***	0.201	-0.213	-0.170	0.657**	-0.416	-0.258
	(0.994)	(-0.336)	(-0.275)	(2.100)	(-0.547)	(-0.324)
Underwr_ROA < 0 ×	-0.002	0.084***	0.083***	-0.021	0.012	0.023
Num_Analysts	(-0.122)	(2.685)	(2.688)	(-0.434)	(0.128)	(0.235)
Underwr_ROA > 0 ×	-0.025	0.020	0.012	-0.122**	-0.053	-0.072
Num_Analysts	(-1.322)	(0.390)	(0.224)	(-2.618)	(-0.516)	(-0.650)
Num_Analysts	-0.001**	-0.002**	-0.003**	-0.001	-0.004	-0.005
	(-2.409)	(-2.029)	(-2.138)	(-0.849)	(-1.347)	(-1.482)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
R-squared	0.385	0.182	0.177	0.427	0.171	0.166
N	3,725	3,725	3,606	1,859	1,859	1,800

Table 9: Implied cost of capital and the underwriting risk

This table presents coefficient estimates from OLS regressions of implied cost of capital on quarterly underwriting and investment performance results. *Cost of capital (PEG)* is the implied cost of capital based on Easton (2004). *Cost of capital (GM)* is the implied cost of capital based on Gode and Mohanram (2003). *Cost of capital (GG)* is the implied cost of capital based on Gordon and Gordon (1997). *Cost of capital (GLS*) is the implied cost of capital based on Gebhardt, Lee, and Swaminathan (2001). The sample includes 86 property and liability insurers from 1995Q1 through 2016Q3. *Controls* represent all other control variables presented in Table 3. *t*-statistics with standard errors adjusted for heteroskedasticity and clustered at a firm level are reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

Panel A: Summary statistics of implied cost of capital

	N	Mean	StDev	10th %tile	Median	90th %tile
Cost of capital (PEG)	2462	0.126	0.156	0.033	0.101	0.208
Cost of capital (GM)	2420	0.137	0.109	0.048	0.119	0.232
Cost of capital (GG)	2757	0.087	0.054	0.040	0.087	0.140
Cost of capital (GLS)	2737	0.039	0.030	0.016	0.036	0.062

Panel B: The impact of underwriting results on the implied cost of capital

	Cost of Capital (PEG)			*Cost of Capital (GM)*			*Cost of Capital (GG)*			*Cost of Capital (GLS)*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	CAPM	3-Factor	4-Factor	CAPM	3-Factor	4-Factor	CAPM	3-Factor	4-Factor	CAPM	3-Factor	4-Factor
Underwr_ROA	-2.848***	-3.175***	-3.202***	-1.154***	-1.276***	-1.280***	0.021	-0.013	-0.006	-0.046	-0.100**	-0.088*
	(-5.628)	(-5.120)	(-5.349)	(-4.478)	(-4.849)	(-4.722)	(0.342)	(-0.200)	(-0.098)	(-0.727)	(-2.207)	(-1.912)
Inv_ROA	0.301*	0.167	0.137	0.207*	0.138	0.177	-0.117	-0.119	-0.132*	0.080	0.076	0.069
	(1.728)	(1.036)	(0.877)	(1.672)	(1.159)	(1.491)	(-1.497)	(-1.508)	(-1.668)	(1.607)	(1.511)	(1.378)
MKT	0.068***	0.018*	0.019*	0.028***	-0.000	-0.003	0.007***	0.005	0.007*	0.007***	0.001	0.002
	(4.972)	(1.863)	(1.682)	(3.091)	(-0.012)	(-0.527)	(2.708)	(1.466)	(1.758)	(4.019)	(0.657)	(1.223)
HML		0.010*	0.012**		0.009*	0.012***		-0.001	-0.001		0.002**	0.002*
		(1.891)	(2.142)		(1.941)	(2.814)		(-0.283)	(-0.680)		(2.070)	(1.933)
SMB		0.026**	0.021**		0.013**	0.011**		0.000	0.000		-0.000	-0.000
		(2.486)	(2.441)		(2.250)	(2.216)		(0.296)	(0.012)		(-0.075)	(-0.358)
LIQ			0.116***			-0.039			0.032*			0.021*
			(2.789)			(-1.230)			(1.741)			(1.788)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	2,460	2,461	2,385	2,418	2,418	2,418	2,755	2,755	2,673	2,149	2,149	2,068
R-squared	0.443	0.432	0.440	0.413	0.413	0.419	0.242	0.241	0.249	0.337	0.330	0.326

Table 10: Underwriting performance and the cost of capital – System GMM approach

This table presents coefficient estimates from system GMM regressions (Equation 7) of the cost of capital on *Underwr_ROA* using two lagged values of the *Underwr_ROA* and their differences as its instrumental variables (Blundell and Bond, 1998). The sample includes 92 property and casualty insurers from 1995Q1 through 2016Q3. The dependent variables are different measure of the cost of capital described in earlier tables. *Controls* include *LogAssets, Capital ratio, P//L assets ratio, Industry combined ratio, Term spread, Default spread, Dividend yield, NBER recession*. *t*-statistics with standard errors adjusted for heteroskedasticity and arbitrary forms of auto- and cross-sectional correlation are reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is denoted by *, **, and ***, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	CAPM	3-Factor	4-Factor	PEG	GM	GG	GLS
Undwr_ROA	-0.297***	-1.177***	-1.029***	-2.714**	-1.021***	-0.150	-0.131
	(-6.923)	(-6.184)	(-5.212)	(-2.302)	(-2.642)	(-1.156)	(-1.325)
Inv_ROA	0.026	0.197*	0.215*	0.122	0.125	-0.153	-0.053
	(0.984)	(1.656)	(1.735)	(0.689)	(0.763)	(-1.530)	(-0.824)
Lagged cost of capital	0.258***	0.101***	0.097***	0.477***	0.296***	0.042	0.109
	(15.516)	(6.280)	(5.914)	(7.458)	(3.574)	(1.048)	(1.615)
Controls	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES
N	3,464	3,464	3,353	2,158	2,116	2,532	2,518