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An Empirical Investigation of the Pricing of Financially Intermediated Risks with Costly External Finance

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ABSTRACT

Under perfect market conditions, theory predicts the hurdle rate on financially intermediated products should reflect only non-diversifiable risk and be constant across all financial institutions. However, recent research by Froot and Stein (1998), among others, suggests imperfections in external capital markets can lead even completely diversifiable risks to impose internal frictional costs specific to the institution and these costs should be allocated back to the individual line of business that generates the costs. We test the costly external finance hypothesis by investigating differences in prices of insurance risks across a sample of U.S. property-liability insurers. The results provide strong evidence supporting the theoretical propositions that the prices of illiquid, intermediated risks vary across firms depending upon the firm’s access to capital markets and by the risk of the individual line of insurance relative to the riskiness of firm’s entire portfolio. Specifically, insurance prices are directly related to either the marginal capital allocations as suggested by the capital allocation method proposed by Myers and Read (2001) or by the covariability of a product with the firm’s overall portfolio consistent with Froot and Stein. Thus, the presence of costly capital and non-tradability implies that prices depend upon risks that are non-systematic and that price dispersion is an equilibrium outcome in insurance markets.

Key Words: Capital Allocation; Price of Insurance
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1. Introduction

The law of one price dictates that identical assets must have identical prices. For example, an ounce of gold trading in London should have the same price as an ounce of gold trading in New York. Arbitrage is the mechanism that enforces the law of one price. However, in order for arbitrage to be fully effective, the asset in question must trade in competitive, liquid markets with no significant transactions costs or barriers to trade. Violations of these conditions can lead to departures from the law of one price. In particular, there is increasing recognition that the law does not necessarily apply to intermediated risks.

Froot and Stein (1998) develop a model of capital budgeting for financial institutions where the pricing of intermediated risks incorporates pricing factors that are not reflected in standard perfect markets financial pricing models. They posit that banks and other financial institutions invest in liquid assets, which are perfectly hedgeable in financial markets, but also invest in illiquid assets, which are not hedgeable. Examples of non-hedgeable assets in banking include bank loans on small businesses and private equity. Examples in the insurance industry include most types of property-liability insurance policies, including commercial liability insurance and catastrophe reinsurance. The other key feature of their model, which derives from Froot, et al. (1993), is that banks face increasing costs of raising new funds. Because holding capital is costly due to factors such as corporate taxation, regulatory costs, and agency costs, financial institutions optimally do not hold sufficient capital to shelter their operations from random outcomes that deplete capital and are exposed to the risk of potentially having to raise costly external capital. In the Froot-Stein model, costly capital and increasing costs of raising new funds thus give financial institutions a legitimate concern with risk management.

Under the conditions of their model, Froot and Stein (1998) demonstrate that the hurdle rates
for illiquid assets incorporate the standard market covariability term familiar from asset pricing theory as well as a term reflecting the covariability of the unsystematic risk of a non-traded asset with the other non-traded assets in the firm’s portfolio. The market price of the latter factor depends upon the firm’s capitalization. Hence, price is a function of both unsystematic risk and the firm’s capital structure, implying that hurdle rates and thus the prices of non-traded assets may vary across institutions, violating the law of one price.

Also relevant for the pricing of intermediated risks is the theory of capital allocation for financial institutions (e.g., Merton and Perold 1993, Perold 2001, Myers and Read 2001, and Zanjani 2002). The capital allocation literature posits that solvency risk matters to customers of financial institutions because the performance of financial contracts depends upon the solvency of the firm. Because banking and insurance relationships often involve risk transfer and risk management, customers of these institutions are more concerned about solvency risk than are investors or customers of non-financial firms. Hence, the demand for intermediated products is sensitive to insolvency risk, and riskier institutions will command lower market prices for their products. Customer aversion to insolvency risk provides another rationale for risk management.

Capital allocation theories also recognize that risky activities contribute more to insolvency risk than lower-risk activities. This provides the motivation for the allocation of capital by line of business, with the amount of capital allocated by line reflecting the marginal stress placed by each line on the overall insolvency risk of the firm. Thus, other things equal, lines of business that have a larger marginal effect on insolvency risk consume more capital and should have higher prices than less risky lines. Of course, the hurdle rates for riskier projects also may be higher, for the reasons given by Froot and Stein (1998).

The overall prediction of Froot and Stein (1998) and the capital allocation literature is that prices of relatively illiquid, intermediated risk products should depend upon firm capital structure, the covariability of the risks with the firm’s other projects, and their marginal effects on the firm’s
insolvency risk. The objective of the present paper is to provide empirical tests of these theoretical predictions using data from the U.S. property-liability insurance industry. The insurance industry provides an ideal setting for the analysis of these pricing theories because property-liability insurance risks are illiquid and are significantly unhedgeable in the financial market sense.\(^1\) In addition, insurers are known to be subject to significant insolvency risk (Cummins, Grace, and Phillips 1999), and policyholders have only limited protection against insurance insolvencies from state insurance guaranty funds. Finally, underwriting risk and the covariability of insurance losses with asset returns differs significantly across the lines of insurance written by property-liability insurers, such that the marginal contribution to insolvency risk also varies considerably by line.

Our empirical tests are based on two pooled cross-section, time-series samples of U.S. property-liability insurers over the sample period 1997-2002. The first sample consists of the maximum number of insurers with usable data that report to the National Association of Insurance Commissioners (NAIC). We refer to this sample as the \textit{overall sample}. The second sample, which we refer to as the \textit{traded firm sample}, consists of the subset of firms that have traded equity capital. Although we prefer to measure several of the variables used in our analysis based on market value data, only a limited subset of insurers have traded equity capital. Thus, we also utilize the overall sample because it is more representative of the entire industry and because of the gain in degrees of freedom for estimating our regression models.

To measure the price of insurance, we utilize the \textit{economic premium ratio (EPR)} developed by Winter (1994). The EPR is the ratio of the premium revenues for a given insurer and line of insurance to the estimated present value of losses for the line. Theory predicts that the EPR will be

\(^1\) Although insurers can hedge some of their insurance underwriting risk through reinsurance, the limitations of the reinsurance market have been well documented (Berger, et al. 1992, Froot and O’Connell 1997). In particular, reinsurance markets are subject to severe underwriting cycles, alternating between “hard markets,” when prices are high and coverage supply is restricted, and “soft markets,” when prices are more moderate and coverage supply is plentiful. Moreover, reinsurance markets have limited capacity, especially for reinsuring catastrophic losses (Froot 2001). The development of catastrophe bonds and options over the past decade has provided a new hedging mechanism for insurers. However, the volume of risk capital in the insurance securitization market remains rather limited. Hence, insurance risk remains largely illiquid and unhedgeable.
related cross-sectionally to insurer capital structure, the covariability among lines of insurance and
between insurance lines and assets, and the amount of capital allocated to each line of business. To
estimate by line capital allocations, we implement the methodology developed by Myers and Read
(2001). Myers-Read allocate capital marginally by taking the derivative of the intermediary’s
insolvency put option with respect to changes in loss liabilities for each project or line of business.
The methodology provides a unique allocation of 100% of the firm’s capital which is not dependent
upon the distributional assumptions employed for the firm’s assets and liabilities. However, to
implement the methodology, it is necessary to make distributional assumptions. In this paper, we
assume that assets and liabilities are jointly lognormally distributed so that capital allocations are
based on the Black-Scholes exchange option model (Margrabe 1978, Myers and Read 2001).

We believe our methodology provides an especially strong test of theories of pricing
intermediated risks. We do not observe the prices of individual insurance policies and hence are
required to base our price measure on aggregate data by line of insurance. Moreover, we do not
observe individual firm capital allocations and, in fact, insurers generally do not publicly disclose
their capital allocation methodologies. Consequently, our tests are an exercise in applying financial
theory to publicly available data to determine whether the theories can explain cross-sectional
relationships observed in the sample. Because there is a significant chance the predicted relationships
will be obscured due to aggregation, if the predictions are supported by our empirical tests, it would
constitute strong evidence that the theories explain the pricing of intermediated risks.

By way of preview, the tests are generally consistent with the theoretical predictions. The
price of insurance as measured by the EPR is inversely related to insurer insolvency risk, consistent
with prior research (Phillips, Cummins, and Allen 1998). Moreover, prices are directly related to the

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2 This is not to say that we believe the economic premium ratio to be an inferior aggregate price measure. It has been
used extensively in the prior literature and has produced meaningful and interesting results (e.g., Winter 1994,
Cummins and Danzon 1997). The EPR is more meaningful than the traditional unit price of insurance, which is
defined as the premium divided by the undiscounted value of losses (e.g., Pauly, et al. 1981). Because premiums
will reflect discounting of losses in a competitive market, the EPR improves upon the unit price by also discounting
the losses in the denominator of the ratio.
amount of capital allocated to lines of insurance by the Myers-Read model and is also directly related to the covariability of losses across lines of insurance. The results thus support the predictions of both Froot and Stein (1998) as well as the capital allocation literature. Our research adds to the growing body of empirical evidence supporting the theories of the pricing of intermediated risks (e.g., Baker and Savasoglu 2002, Naik and Yadav 2003).

The remainder of the paper is organized as follows: In section 2, we review the relevant literature on intermediated risk and capital allocation and formulate our hypotheses in more detail. Section 3 discusses sample selection and methodology. The results are presented in section 4, and section 5 concludes the paper.

2. Literature Review and Hypotheses

Froot and Stein (1998) hypothesize that financial institutions care about risk management because they face convex costs of raising external capital. Holding capital is costly due to various frictional costs such as corporate income taxation, agency costs, and regulatory costs. Hence, institutions do not hold sufficient capital to eliminate the possibility of having to raise external capital under unfavorable conditions due to adverse investment outcomes. Convex costs of raising external capital along with the frictional costs of holding capital provide the motivation for intermediaries to engage in risk management. In addition, financial institutions are hypothesized to invest in illiquid assets which cannot be fully hedged in financial markets.

Under these conditions, the hurdle rates and hence the prices of illiquid intermediated risk products are shown to be generated by a two-factor model, consisting of the standard market systematic risk factor and a factor reflecting the covariability of the risk product’s returns with the bank’s pre-existing portfolio of non-tradeable risks. The price of the latter covariability term depends upon the bank’s effective risk aversion, which is a function of the convexity of the cost function for external capital as well as the level of capitalization of the institution. Specifically, the price is

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3 The introduction of convex capital costs as a motivation for risk management is due to Froot, Scharfstein, and Stein (1993).
inversely related to the amount of capital held by the bank. Thus, the principal predictions are that the price of an intermediated risk will be positively related to its covariability with the other risks in the institution’s portfolio and will be inversely related to the institution’s capitalization.\(^4\)

In addition to the costly external finance hypothesis, the prediction that hurdle-rates may vary across intermediated risks can be drawn from the capital allocation literature. An important early paper on capital allocation is Merton and Perold (1993), who, like Froot and Stein, suggest the motivation for capital allocation is provided by customer aversion to insolvency risk. Although this risk aversion is somewhat blunted in commercial banks due to deposit insurance, there is empirical evidence risk aversion is still present due to bank sales of products not covered by government insurance programs (see, for example, Hannan and Hanweck 1988). Merton-Perold adopt an “incremental” approach to allocating capital. They consider an institution with N lines of business and calculate its insolvency put value. They then sequentially subtract each line of business and measure the insolvency put for the N-1 line institution. The capital allocation for line i is then the additional capital required to maintain the same relative insolvency put value when adding line i to a bank consisting of the other N-1 lines. The principal problem with the Merton-Perold methodology is that it does not allocate 100% of the institution’s capital. Their approach is appropriate when considering mergers and acquisitions and divestitures of entire divisions or lines of business but is less appealing when considering the pricing of individual products such as bank loans or insurance policies which represent only marginal changes in the composition of the firm.

The contribution of Myers-Read (2001) was to introduce a marginal capital allocation model that uniquely allocates 100% of the intermediary’s capital. They hypothesize an N line firm and calculate marginal capital allocations by taking the derivative of the firm’s overall insolvency put value with respect to loss liabilities of each of the N lines. The methodology is not dependent upon

\(^4\) In a recent extension, Froot (2003) considers the case where the underlying risk is asymmetric about the location of the distribution. Relaxing the assumption of symmetry results in a third factor related to the degree of the asymmetry. We acknowledge the existence of the work here and plan to develop to specifically incorporate this new result in a later version of this paper.
any particular set of distributional assumptions with respect to the firm’s asset or liability returns. However, they illustrate the model under the assumptions that assets and liabilities are jointly normal and lognormal, respectively. The latter assumption involves modeling the firm as a Black-Scholes exchange option, where returns on total assets and total liabilities are jointly lognormal.

Because all lines of insurance have equal priority in bankruptcy, Myers-Read argue that the most sensible approach is to allocate capital so that the marginal contribution of each line of business to the insolvency put value is equal. This ensures that there is no cross-subsidization across line of insurance. We adopt the approach of equating the marginal default valued among lines in the empirical part of this paper.

Although Myers-Read do not explicitly consider the issue of hurdle rates, a logical implication of their paper is that the price of given line of insurance should be directly related to the amount of capital allocated to the line at the margin. The covariability of the line’s return distribution with the return distributions for the firm’s other business lines and its asset portfolio is embedded in the capital allocation through its effect on the firm’s overall insolvency put value. However, the covariability presumably could be reflected in the price through the hurdle rate as well, through a pricing model such as Froot-Stein (1998).

The Myers-Read model clearly has normative implications for insurance management and regulation. However, in this paper we hypothesize that it also has positive implications for insurance markets as an implicit underlying hypothesis is that cross-sectional differences in insurance prices can be partially explained by Myers-Read capital allocations. In order for this hypothesis to be correct, it is not necessary that insurance companies actually allocate capital according to the Myers-Read model. It is only necessary that, through the operation of insurance markets, risks are priced in such a way that prices reflect the marginal burden that specific risks place on the insolvency risk of insurers. This requires only that markets are sufficiently rational that on average insurers are able to assess the riskiness of policies that are being priced and that their price quotes to prospective buyers
reflect these insolvency risk assessments. Given that accurate assessment of underwriting risk is a necessary core competency of successful insurers, this seems to be a reasonable assumption.

The final important theoretical paper that forms the foundation for the hypotheses tested here is Zanjani (2002). Zanjani adds to the literature by incorporating elements from both the Froot-Stein (1998) model as well as from Myers-Read (2001) and other capital allocation papers. In effect, the present paper can be viewed most directly as providing an empirical test of Zanjani’s hypotheses.

Zanjani’s model rests on three key assumptions: (1) Loss outcomes are risky, so insurers face significant insolvency risk, (2) it is costly for firms to hold capital, and (3) the risk of insolvency matters to consumers. The rationale for costly capital is much the same as in the prior literature, i.e., frictional costs such as agency costs and corporate taxation; and the argument that consumers care about solvency risk is consistent with Merton and Perold (1993), Merton (1995), among others. The existence of costly capital as well as consumer demand for solvency leads to insurer risk aversion and provides the rationale for risk management. Insurers thus “will pay to avoid risk and charge to bear it, with the risk charge in a given market segment being determined by that segment’s associated marginal capital requirement. Price differences across market segments are therefore explained by differences in marginal capital requirements (Zanjani 2002, p. 284).” As in Froot and Stein (1998), unsystematic risk matters in the pricing of intermediated risk products; and, as in Myers-Read (2001), marginal capital requirements play an important role in explaining cross-sectional price differences.

The predictions of Zanjani’s model can be summarized in terms of the factors determining the price for a marginal change in a given line of insurance (e.g., issuing a policy that does not significantly change the scale of operations in the line): (1) Marginal production costs (i.e., administrative and marketing expenses); (2) expected claim costs net of expected cost savings due to the limited liability default option; (3) the usual capital market systematic risk term, (4) a term representing the frictional costs of holding capital, and (5) the marginal cost of the capital required to
maintain constant financial quality (insolvency risk). The first and second components are standard elements of insurance pricing; while the third and fourth components are also familiar from the prior literature.\footnote{Frictional costs of capital were first introduced in an insurance pricing model by Myers and Cohn (1987).} In the Myers-Read construct, the fifth term reflects the cost of adjusting capital to maintain a constant insolvency put value relative to liabilities. In an interesting special case, where financial quality is assumed to be a one-to-one function of the probability of default rather than being represented by the insolvency put, Zanjani shows that the fifth term reduces to a function of the cost of capital and a beta coefficient for the line, which reflects the covariability of the ith line’s underwriting risk with the underwriting risk of the firm’s overall portfolio, similar to the firm-wide risk factor in Froot-Stein (1998).

The review of the literature suggests three primary hypotheses based on the literature on intermediated risks and capital allocation:

**Hypothesis 1:** The price of insurance is inversely related to the overall insolvency risk of insurance companies.

This hypothesis, which is consistent with Zanjani (2002) and earlier papers such as Phillips, et al. (1998) and Cummins (1988), essentially reflects the pricing of insurance as risky debt. The second hypothesis relates to the pricing of individual lines of insurance:

**Hypothesis 2:** Controlling for overall insolvency risk, the price of insurance across lines of business is directly related to the marginal contribution of the business lines to insurer insolvency risk.

Hypothesis 2 is primarily based on Myers and Read (2001) and Zanjani (2002). The final hypothesis is closely related to Hypothesis 2 but with slightly different implications:

**Hypothesis 3:** Controlling for overall insolvency risk, the price of insurance across lines of business is directly related to the covariability of specific lines of business with the firm’s overall liability portfolio.

Given that covariability also affects the marginal contribution of individual lines of insurance to overall insolvency risk, Hypothesis 3 overlaps somewhat with Hypothesis 2. However, in models such as Froot-Stein (1998), covariability is priced even though capital allocation does not play a
significant role. Thus, in this sense, the two hypotheses are distinct.

3. Sample Selection and Methodology

Sample Selection

To test the hypotheses specified in section 2, we need to estimate the price of insurance by line, the variances and covariances of insurer asset and liability portfolios, the firm’s overall insolvency risk, and the marginal contributions of lines of business to insolvency risk. To estimate these quantities as well as control variables, we select two pooled cross-section, time-series samples of U.S. property-liability insurers over the sample period 1997-2002. The first sample consists of the maximum number of insurers with usable data that report to the National Association of Insurance Commissioners. We refer to this sample as the overall sample. The second sample, which we refer to as the traded firm sample, consists of the subset of firms that have traded equity capital. The reason for choosing two samples is that only a subset of U.S. property-liability insurers are publicly traded. The number of observations in the overall sample is 8,010, and the number of observations in the traded firm sample is 362. Thus, although we prefer to measure some of the key variables using market value data, the overall sample is important because it is representative of the entire industry and because of the gain in degrees of freedom for estimating our regression models.

Our primary data source for the study consists of the regulatory annual statements filed by insurers with the National Association of Insurance Commissioners (NAIC). To calculate the variance covariance matrix of insurer liability portfolios, we also utilize the NAIC by-line quarterly database. This database contains a subset of the data from the NAIC annual statement database, and importantly includes data on underwriting returns needed to estimate the variance-covariance matrix. For the traded firm sample, data on stock returns were obtained from the Center for Research on Securities Pricing (CRSP) database for stocks traded on the New York Stock Exchange (NYSE), the American Stock Exchange (AMEX), and the NASDAQ. Some financial statement data for the traded firms were obtained from Computstat.
Estimating the Price of Insurance

The definition of the price of insurance used in this study is the economic premium ratio (EPR). The EPR has become the standard price measure in the insurance financial literature (e.g., Winter 1994, Cummins and Danzon 1997, Cummins, Phillips, and Allen 1998). The EPR for a line of insurance is defined as the ratio of the premiums for the line to the expected value of losses discounted at the risk-free rate (Winter 1994). The rationale for discounting is that premiums in a competitive insurance market will reflect the present value of expected loss cash flows. Thus, the EPR uses present value concepts in both the numerator and denominator of the ratio. Moreover, using actual premiums in the numerator and the riskless present value of losses in the denominator allows us to capture inter-firm differences in prices due to insolvency risk because competitive premiums will reflect a discount for the insolvency put option.

More precisely, the EPR is defined as follows:

\[ EPR_{ij} = \frac{NPW_{ij} - DIV_{ij} - E_{ij}}{\sum_{t=1}^{T} (NLI_{ijt} + LAE_{ijt})/(1 + r_f)^t} \]

where \( EPR_{ij} \) = the economic premium-to-liability ratio for line i, company j,

\( NPW_{ij} \) = net premiums written for line i, company j,

\( DIV_{ij} \) = policyholder dividends incurred for line i, company j,

\( E_{ij} \) = underwriting expenses incurred for line i, company j,

\( NLI_{ijt} \) = net loss cash flow for line i, company j, at time period t following policy issuance,

\( LAE_{ijt} \) = net loss adjustment expense cash flow for line i, company j, at time period t,

\( r_f \) = U.S. Treasury spot-rate of interest for maturity of t,

T = the number of periods in the loss cash flow stream.
EPR\textsubscript{ij} is calculated separately for each company and year of the sample period.\textsuperscript{6} Because underwriting expenses vary significantly across lines of insurance and the objective is to focus on the part of the premium that compensates the insurer for bearing risk, underwriting expenses and policyholder dividends are netted when computing the economic premium ratio. This focuses the analysis on the part of the premium that compensates the insurer for the discounted value of expected losses and loss adjustment expenses.

Insurance policies issued in any given year give rise to loss and loss adjustment expense cash flows for several years into the future, depending on the length of the “payout tail” for each line of insurance. The calculation of the EPR thus requires the estimation of the loss cash flows arising out of each year’s policies. The loss cash flows are estimated by multiplying the total incurred losses and loss adjustment expenses for the year by estimated payout tail proportions for each line of business. The payout tail proportions were estimated using the Taylor separation method, a standard actuarial technique for estimating loss payouts (see Taylor 2000). Data to implement the Taylor methodology were obtained from industry-wide regulatory annual statement data provided in Best’s Aggregates and Averages (1997-2002). The calculation of loss present values also requires estimates of the U.S. Treasury spot-rate yield curves for each year of the sample period. The spot rates of interest were extracted by bootstrapping the yield curve from the constant maturity treasury data provided in the Federal Reserve Bank of St. Louis’ Federal Reserve Economic Data (FRED) database.

\textbf{Estimating the Variance-Covariance Matrix of Returns}

In order to implement the Myers-Read methodology, we need estimates of the firm’s variance-covariance matrix, including both the liability portfolio and the asset portfolio. To implement the model for the widest possible sample of firms, we aggregate each insurer’s lines of

\textsuperscript{6} The year subscript is suppressed in equation (1) to simplify the notation.
business into two primary categories – property lines of business and liability lines of business. A highly aggregated grouping was necessary because most firms in the sample operate in only a subset of the twenty-one major lines of business offered by the property-liability insurance industry. However, nearly all firms in the sample write some property lines and some liability lines. The breakdown of lines of business between property and liability is based on the rationale that property lines are generally short-tail lines of business where loss cash flows occur in a relatively limited period following the year of policy issue, whereas liability lines have cash flows covering more extended periods. In addition, the nature of the risks covered by property and liability insurance are also significantly different, i.e., property damage from various causes versus tort liability, respectively. As a robustness check, we also conducted the analysis based on other line groupings, such as personal and commercial lines, with similar results.

Because annual data were not considered adequate to estimate the variance-covariance matrix, we base the calculation on quarterly data on losses and premiums by line provided by the NAIC. Quarterly data were available from 1991-2002, and the entire data series was used in the analysis. To calculate the variance-covariance matrix, we define the rate of return series by line of insurance as the economic loss ratio (ELR), defined as the present value of incurred losses and loss adjustment expenses for each quarter divided by premiums for the quarter. Normalizing by premiums is important to control for volume changes over the sample period. The loss ratio is a standard measure of underwriting returns in the property-liability insurance, and the economic loss ratio corrects the usual loss ratio to reflect present value concepts in both numerator and denominator. Loss present values were calculated using the same payout tail estimates employed in calculating the economic premium ratios, but the yield curves vary quarterly in the economic loss ratio calculation.  

Specifically, the property insurance includes the following lines: Homeowners, Farmowners, Automobile Physical Damage, Special Property, Fidelity and Surety, Commercial Multiple-Peril, and All Others. The liability lines of business include Private and Commercial Automobile Liability, Workers’ Compensation, Medical Malpractice, Special Liability, Other Liability, Products Liability, Reinsurance, and International.

The payout tail proportions are held constant over our time period for two reasons: (1) the data required to estimate the proportions are only available annually; and (2) prior research suggests payout tail proportions are quite...
For the analysis of the asset portfolio, we grouped insurer assets into seven categories – stocks, government bonds, corporate bonds, real estate, mortgages, cash and other invested assets, and non-invested assets, where the latter category includes receivables from agents and reinsurers, electronic data processing equipment, and other miscellaneous assets. Standard rate of return series are used to obtain quarterly estimates of the returns on the first six asset categories. The 30-day Treasury bill rate is used as the return series for the non-invested asset category.

The quarterly time series of underwriting returns on the property and liability lines and on the seven categories of assets are used to calculate the variance-covariance matrices of insurer assets and liabilities as well as cross-covariances between underwriting returns and the asset categories. The calculation was conducted once, based on the entire time series of returns from 1991-2002. As a robustness check, we also conducted the analysis with the covariance matrix for year \( t \) estimated based on quarterly data through the end of year \( t-1 \), with similar results. We chose to calculate the variance-covariance matrix using industry-wide data rather than firm data because some of the individual firm data series were relatively noisy, being based on relatively small premium writings. As a robustness check, we also conducted the analysis using firm-specific time series of underwriting returns. The results were somewhat noisier but support the same conclusions.

**Estimating the Myers -Read Marginal Capital Allocations**

As mentioned above, we adopt the Myers-Read methodology to calculate capital allocations by line of business, and, specifically, utilize the assumption that assets and liabilities are jointly lognormally distributed so that the Black-Scholes exchange option framework can be employed. The two state variables in the Myers-Read model are the market value of the firm’s assets, \( V \), and the present value of its loss liabilities, \( L \). The firm’s overall capital, called surplus in the insurance

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9 The rate of return series are as follows: (1) Equities – the total return on the Standard & Poor’s 500 Stock Index; (2) government bonds – the Lehman Brothers intermediate term total return; (3) corporate bonds – Moody’s corporate bond total return; (4) real estate – the National Association of Real Estate Investment Trusts (NAREIT) total return; (5) mortgages – the Merrill Lynch mortgage backed securities total return; and (6) cash and invested assets, the 30-day U.S. Treasury bill rate.
industry, is then defined as \( S = V - L \). Define the firm’s default value (insolvency put option) as \( D(V,L,t,r_f,s) \), where \( D(\bullet) = \text{the insolvency put} = PV[\text{Max}(0,L-V)] \), \( t \) = time to expiration of the option, \( r_f \) = the risk-free rate of interest, \( \sigma = \sqrt{\sigma_L^2 + \sigma_V^2 - 2\sigma_{LV}} \) = the firm’s overall volatility parameter, \( \sigma_L^2 \) = the volatility of the firm’s losses, \( \sigma_V^2 \) = the volatility of the firm’s assets, and \( \sigma_{LV} \) = the covariance of the natural logs of losses and asset values (log losses and log assets).

Myers-Read then decompose loss liabilities by line, such that \( L = \sum_{i=1}^{M} L_i \), where \( L_i \) = present value of liabilities for line \( i \) and \( M \) = the total number of lines of business. In our analysis, we also decompose assets into the primary categories discussed above, such that \( V = \sum_{i=1}^{N} V_i \), where \( V_i \) = amount of assets of type \( i \) and \( N \) = the number of asset categories. Also define \( x_i = L_i/L \) and \( y_i = V_i/V \). Then the components of the volatility parameter \( \sigma \) are defined as:

\[
\sigma_L^2 = \sum_{i=1}^{M} \sum_{j=1}^{M} x_i x_j \rho_{L_i L_j} \sigma_{L_i} \sigma_{L_j} \tag{2}
\]

\[
\sigma_V^2 = \sum_{i=1}^{N} \sum_{j=1}^{N} y_i y_j \rho_{V_i V_j} \sigma_{V_i} \sigma_{V_j} \tag{3}
\]

\[
\sigma_{LV}^2 = \sum_{i=1}^{N} \sum_{j=1}^{M} y_i x_j \rho_{V_i L_j} \sigma_{V_i} \sigma_{L_j} \tag{4}
\]

where \( \rho_{L_i L_j} \) = the correlation coefficient of the logs of loss series \( i \) and \( j \),

\( \rho_{V_i V_j} \) = the correlation coefficient of the logs of asset classes \( i \) and \( j \),

\( \rho_{V_i L_j} \) = the correlation coefficient of the logs of asset class \( i \) and liability class \( j \),

\( \sigma_{V_i} \) = the standard deviation of the log of asset class \( i \), and

\( \sigma_{L_j} \) = the standard deviation of the log of liability class \( j \).

The Myers-Read capital allocations are derived by taking the derivatives of the insolvency
put value $D$ with respect to the loss liabilities in each line, i.e., $d_i = \frac{\partial D}{\partial L_i}$. In this paper, we assume that the operation of the competitive insurance market results in the equalization across lines of the marginal default values. In this case, Myers-Read show that the firm’s surplus, $S$, is allocated across lines of business such that the allocated surplus per dollar of liabilities in line $i$ is:

$$s_i = s - \left(\frac{\partial d}{\partial s}\right)^{-1} \left(\frac{\partial d}{\partial \sigma}\right) \left[\sigma_{L_i L} - \sigma_{L_i L}^2\right] \left(\sigma_{L_i V} - \sigma_{L_i V}\right)$$

(5)

where $s_i = \text{allocated surplus per dollar of liabilities for line } i = \frac{S}{L_i}$,

$s = \text{the overall surplus-to-liability ratio of the firm} = \frac{S}{L}$,

$\sigma = \text{firm’s overall volatility parameter}$,

$d = \text{the firm’s insolvency put per dollar of total liabilities} = \frac{D}{L}$,

$\frac{\partial d}{\partial s} = \text{the partial derivative of } d \text{ with respect to } s \text{ (the option delta)}$,

$\frac{\partial d}{\partial \sigma} = \text{the partial derivative of } d \text{ with respect to the overall volatility parameter } \sigma \text{ (the option vega)}$,

$\sigma_{L_i L} = \text{the covariance between the log of losses in line } i \text{ and losses of the liability portfolio}$,

$\sigma_{L_i V} = \text{the covariance between the log of losses in line } i \text{ and the log of assets}$.

Thus, because $\frac{\partial d}{\partial s} < 0$ and $\frac{\partial d}{\partial \sigma} > 0$, line $i$’s capital allocation is directly proportional to its covariability with the loss portfolio ($\sigma_{L_i L}$) and inversely proportional to its covariability with the asset portfolio ($\sigma_{L_i V}$). Lines that contribute more (less) to the covariability of the loss portfolio increase the firm’s overall risk level and therefore require more (less) capital. However, because the firm’s overall volatility parameter is inversely related to the covariability between assets and liabilities, lines with higher covariability with assets require less equity capital. Intuitively, positive correlation between assets and liabilities creates a natural hedge that reduces the risk of the firm.

We implement the Myers-Read model using the estimated variance-covariance matrix for assets and liabilities based on the quarterly underwriting and asset return series discussed above. The time to maturity of the default option is set at 1 year based on the rationale that insurers are subjected
to rigorous regulatory audit tests on an annual basis. Thus, the put option is potentially exercisable by the regulator at approximately one year intervals.\textsuperscript{10} The firm’s overall surplus-to-liability ratio, $s$, and the by-line capital allocation ratios, $s_i$, are then used as explanatory variables in our regression analysis in order to test Hypothesis 2.

**Market-Based Estimates of Firm Risk**

We use a market-based estimate of firm insolvency risk in analyzing the sample of publicly traded firms. Specifically, we extend the Ronn and Verma (1986, 1989) option pricing methodology to derive market measures of the riskiness of the insurer. In applying the Ronn and Verma methodology, we extend their approach in two important ways. First, our approach allows us to obtain estimates of an insurer’s insolvency put which recognize that the insurance company’s liabilities evolve as stochastic processes, whereas Ronn and Verma assume that bank liabilities are non-stochastic.\textsuperscript{11} Second, we control for potential bias induced by the non-synchronous trading observed in the stock of several of the smaller companies in the sample. Non-synchronous trading can significantly bias equity return volatility estimates.

The Ronn-Verma methodology estimates the market value of the assets of the firm, $A$, and the implied volatility of the value of the firm, $\sigma_x$, by solving the following two simultaneous equations based on the formula for the owners’ equity call option:

\begin{align*}
E &= V N(d_1) - L e^{-rT} N(d_2) \\
\sigma_E &= \frac{N(d_1) V}{E} \sigma_x
\end{align*}

where $E =$ the market value of equity,

$V =$ the market value of assets,

\textsuperscript{10} See Pennacchi (1987) and Cummins (1988). Of course, regulators have the authority to audit more frequently if they receive reports that an insurer is encountering financial difficulties. Typically, however, insurer capital adequacy is evaluated annually based on regulatory audit tests and risk-based capital rules (Cummins, Grace, and Phillips 1999). Thus, although the one year time horizon is clearly an approximation, it should provide a reasonable representation of reality.

\textsuperscript{11} See Phillips, Cummins, and Allen (1998) for the derivation of the extended option pricing model.
L = the present value of liabilities,

x = the asset-to-liability ratio = V/L,

t = time until payment of loss liabilities,

r = the risk-free interest rate net of the growth rates of the insurer’s liabilities (i.e., the risk-neutralized drift term on the process x = V/L),

s_x = the diffusion parameter of the process x = V/L, a function of the diffusion and covariance parameters of the asset and liability processes,

s_E = the standard deviation of the firm’s equity returns,

d_1 = [ln(V/L)+(r_rL+0.5s_x^2)t]/(s_x%t),

d_2 = d_1 - s_E% , and

N(Q = the standard normal distribution function.

The equity return standard deviation (s_E) was estimated using both daily and weekly data. The daily standard deviations of equity returns are based on the most recent 200 trading days before the end of the year, while the weekly estimates are based on the most recent 40 weeks of weekly return data prior to the end of the year. The daily measures were annualized by multiplying the daily standard deviation by the square root of the number of trading days during the year, and the weekly measures were annualized by multiplying by the square root of 52 weeks. In estimating s_E, we correct for biases created by non-synchronous trading using the procedure developed in Smith (1994).

In evaluating equations (6) and (7), the market value of equity, E, for the insurance company was set equal to the market capitalization of the firm as reported in the CRSP data base for December 31 of each study year. The total liabilities of the firm, L, were obtained from the consolidated balance sheets as reported in the firm’s 10-K form. The discount rate, r_r, for each company is (see Phillips, Cummins, and Allen, 1998, for the derivation):

\[ r_x = r_f - \left[x_1r_{t_1} + x_2r_{t_2} + \ldots + x Mr_{t_M}\right] \] (8)

where \( r_{t_i} \) = the drift term in a geometric Brownian motion process describing the evolution of the ith
class of liabilities, and \( r_f \) = the risk-free rate.

Following Phillips, Cummins, and Allen (1998), the liability drift term \( r_{Li} \) for line of business \( i \), was estimated as the average five-year growth rate of total industry accident year losses and loss adjustment expenses incurred for each line of business. For each year of the sample period, five-year growth rates for the period ending on December 31 of the year were used. The weights, \( x_i \), used in equation (8) vary by insurer and are estimated from the data on incurred losses and loss adjustment expenses by line reported in the NAIC annual statement database. As in the Myers-Read analysis, lines were grouped together into property and liability categories; and the time to maturity, \( t \), was set equal to 1 year, based on the rationale that regulatory audits are performed annually.

**Regression Analysis**

In order to test Hypotheses 1, 2, and 3, we conduct a series of multiple regression analyses. The dependent variables in the regressions are economic premium ratios. The explanatory variables include variables to test the hypotheses as well as control variables. Pooled, cross-section, time series regressions are conducted using data on all sample firms over the entire sample period. To maximize the number of firms included in the analysis and avoid survivor bias, the regressions are based on unbalanced panel data. The basic regression specification is as follows:

\[
EPR_{ijt} = \beta_0 + \beta_1 D_{jt} + \beta_2 s_{jt} + \beta_3 \frac{s_{ijt}}{s_{jt}} + \gamma X_j + \nu_{ij} + \eta_{it} + \epsilon_{ijt}
\]  

(9)

where \( EPR_{ijt} \) = the economic premium ratio for insurance line \( i \), for insurer \( j \), in year \( t \),

\( D_{jt} \) = proxy for insurer \( j \)'s default risk in year \( t \),

\( s_{jt} \) = the overall surplus-to-liabilities ratio for insurer \( j \) in year \( t \),

\( s_{ijt} \) = the Myers-Read surplus-to-liabilities ratio for line \( i \), insurer \( j \), in year \( t \),

\( X_j \) = vector of control variables for insurer \( j \),

\( \nu_{ij} \) = firm fixed effect for line \( i \), insurer \( j \),
\[ \eta_{it} = \text{year fixed effect for line } i, \text{ and} \]
\[ \epsilon_{ijt} = \text{random error term for line } i, \text{ insurer } j, \text{ in year } t. \]

A separate model is estimated for each line of insurance – property and liability insurance – included in the analysis. The regression models are estimated by ordinary least squares with a correction for heteroskedasticity. The most fully specified versions of the regressions utilize firm and year fixed effects. Tests with random effects models yielded similar results. Because capitalization, business mix, and prices are likely to differ among members of insurance groups and because groups have the option to allow individual member companies to become insolvent, the analysis in the overall sample is conducted at the company level rather than the group level. In the traded firm sample, because we make use of firm-wide market value data, the analysis is conducted at the group level.

We use two different variables to test Hypothesis 1 that price is inversely related to firm insolvency risk of the insurer. In the overall sample analysis we measure the financial strength of the insurer using the ratings assigned by the A.M Best Company. In the traded firm sample we use market-based put value estimates based on the Ronn-Verma market value analysis as our proxy for firm risk. We also conduct tests where we replace the insolvency put values with the insurers’ financial ratings assigned by the A.M. Best Company, as an alternative measure of firm financial strength. The predicted sign on the proxy for default risk, \( D \), is negative. In some specifications, we also incorporate the firm’s overall surplus to liability ratio, \( s \), in the regressions. Because it provides an additional measure of the firm financial strength, the expected sign of this variable is positive.

The variable used to test Hypothesis 2, i.e., that lines that consume more capital have higher prices, is the Myers-Read allocated surplus-to-liability ratio for line \( i \), \( s_{ijt} \). This variable is entered in the regression equation in two alternative ways – (1) as a free-standing variable, and (2) as a ratio to the firm’s overall surplus-to-liability ratio \( s \). In both cases, the predicted sign of the variable is
positive, i.e., lines with more allocated capital, either in absolute value or relative to the firm’s overall capital ratio, should have higher prices. In particular, the line-specific capital ratio relative to the firm’s overall capital ratio is a particularly strong test of the hypothesis the absolute variable will likely be correlated with the overall capitalization of the firm whereas the relative truly measuring the contribution of the individual line of insurance to the riskiness of the entire portfolio. To test Hypothesis 3, that lines with higher covariances with the firm’s overall portfolio have higher prices, we enter the estimated covariances of line i’s underwriting return with the firm’s liability portfolio ($\sigma_{LiL}$) in some versions of the regressions in place of the allocated capital to liabilities ratio. We also include the covariability of line i’s return with the asset portfolio ($\sigma_{LiV}$) as an additional variable in some regression models. The expected sign of $\sigma_{LiL}$ is positive, i.e., lines contributing relatively more to the covariance of liabilities should have higher prices. The expected sign of $\sigma_{LiV}$ is negative, i.e., lines whose returns are positively correlated with asset returns should have lower prices because they provide a natural hedge.

Several control variables also are included in the regressions. The growth rate in liabilities in line i, $r_{Li}$, is included. Phillips, et al. (1998) show that the expected sign of this variable is ambiguous. On the one hand, higher growth raises the rate at which the insolvency put value is discounted in the economic premium ratio, increasing the EPR; but, on the other hand, a higher value of $r_{Li}$ increases the insolvency put option, potentially reducing the EPR. A dummy variable is included set equal to 1 for unaffiliated single companies and to zero otherwise. Most insurers are part of insurance groups that own multiple companies. Recall that under the Froot-Stein, Froot, and Zanjani models, prices charged by a firm will reflect the firm’s risk aversion. Insurers that are not members of groups are likely to be more risk averse than group members because they forfeit a source of diversification by not being part of a group. An insurance group can diversify underwriting risk across companies in the group and has the option of recapitalizing a group member than incurs
Recapitalization from a parent or sibling insurers is not possible for an unaffiliated company, possibly leading such firms to have higher risk aversion and higher prices.

In the overall sample regressions, we also include a control variable set equal to 1 for insurers that are owned by publicly traded parents and to zero otherwise. The anticipated sign on this variable is negative. Firms that are owned by publicly traded parents have easier access to capital than privately held stock firms because the parents can issue securities directly in capital markets to raise funds to take advantage of investment opportunities or to recapitalize subsidiaries that suffer adverse loss or investment shocks. Firms owned by publicly traded parents thus may be less risk averse than privately held firms and thus charge lower prices. Another ownership form variable included in the overall sample regressions is a dummy variable set equal to 1 for mutuals and to zero otherwise. The predicted sign on this variable is ambiguous. On the one hand, mutuals have limited access to external capital in comparison with insurers owned by publicly traded parents and perhaps also with respect to privately owned stock firms, leading to a prediction of a positive coefficient, reflecting higher risk aversion for mutuals. On the other hand, within a given market segment, mutuals may underwrite less complex and less risky policies than stock insurers (Mayers and Smith 2000), which require lower risk loadings, such that the sign of the mutual dummy variable could be negative.

The log of firm assets is included in the regressions to control for firm size. The predicted sign of this variable is negative. Larger firms tend to be more diversified than smaller firms and thus may tend to be less risk averse. Finally, the percentage of premiums in price regulated lines (personal auto liability and workers’ compensation) is included in the liability regressions to proxy for the effects of price regulation. We expect the coefficient of this variable to be either insignificant or negative consistent with prior research which shows the average impact on prices is small and slightly negative (but not always significantly so) (Harrington 2002). Finally, the ratio of advertising

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12 Under corporate law, the creditors of an insolvent subsidiary cannot reach the assets of other members of the group unless they are successful in “piercing the corporate veil,” which usually requires a finding of fraud or similar wrong-doing by the group’s owners. Hence, the group could allow individual subsidiaries to fail, exercising the limited liability option.
expenses to total expenses is included as a measure of the strength of the firm’s brand identity. We expect a positive sign on this variable if firms with stronger name brands can charge higher prices.

4. Empirical Results

This section presents the empirical results. We begin by discussing summary statistics on the insurers in the overall and traded firm samples, including the results of the Myers-Read capital allocations. The regression results and empirical evidence on the hypotheses are then discussed.

Summary Statistics

The “economic value” balance sheet for the U.S. property-liability insurance industry for 2000, the mid-point of our sample period, is shown in the upper panel of Table 1. The table is based on the overall firm sample, with the data obtained from the NAIC regulatory annual statement database. Consequently, stocks are reported at market values, but other assets are stated at statutory book values. Policy loss reserves are adjusted to riskless present values by discounting using the U.S. Treasury spot rate yield curve. Cash flow payout patterns were estimated using the Taylor (2000) separation method. Other liabilities are at stated book values.

Table 1 shows that insurers have about 46.5% of their assets in bonds, 23.8% in stocks, and 6.6% in cash and short-term invested assets. Non-invested assets, primarily receivables from agents and reinsurers, represent 22.2% of total assets. On the liability side, 71.9% of liabilities represent reserves for unpaid losses. The industry’s economic equity is $499,413 is larger than the statutory book value of equity by $399,531 primarily due to the discounting of loss reserves in Table 1.

The estimated industry-wide variance-covariance matrix based on the NAIC quarterly loss ratio data and asset return indices is shown in Table 2. As discussed above, the industry’s business lines have been aggregated into two categories – property lines and liability lines. Property lines have higher volatility, measured by the standard deviation of the loss ratio, than do liability lines – 18.0% versus 13.3%. The higher volatility reflects the greater exposure of property lines to

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13 Bonds are valued at amortized cost, mortgages are stated at unpaid principal balances, and real estate is at amortized cost less depreciation.
catastrophes such as hurricanes, earthquakes, and man-made disasters. The correlation between the loss ratios for the property and liability lines is 42.8%. Thus, insurers can achieve significant diversification by operating in both the property and liability lines.

The property lines return series are negatively correlated with most asset returns. In terms of the assets making up the largest shares of insurer portfolios, the property lines have correlations of -43.5% with stocks, -39.8% with corporate bonds, and 6.1% with government bonds. Thus, investing in corporate securities does not provide a hedge against losses in the property lines but rather adds to firm risk. Liability lines are also negatively correlated with stocks and corporate bonds but the correlations are smaller in absolute value than for property lines: -39.0% and -12.7%, respectively. Liability lines are positively correlated with government bonds, 23.3% correlation. Therefore, investing in government bonds has favorable hedging properties for both property and liability lines.

To illustrate the capital allocation results, the lower panel of Table 3 shows the industry-wide capital allocations for the year 2000. This is based on the industry-wide balance sheet shown in Table 1 and the variance-covariance results presented in Table 2. Because loss liabilities have higher volatilities than non-loss liabilities, the amounts of industry capital allocated to the loss liabilities are disproportionate to their share of total industry liabilities. The “all other liabilities” category consists of liabilities such as commissions owed to agents and Federal and state tax liabilities and thus does not constitute a serious insolvency risk exposure to insurers. The capital allocations to property, liability, and all other liabilities are 23.6%, 77.2%, and -0.8%, compared to the breakdown of total liabilities of 16.0%, 55.9%, and 28.1%, respectively. Also of interest are the capital to liability ratios ($s_{ij}$) shown in Table 3, which are 1.18 for property insurance and 1.11 for liability insurance.

Summary statistics for the variables included in the regression analysis are shown in Table 4 for the overall sample and Table 5 for the traded firm sample. The economic premium ratios are shown in the top part of the tables. The property insurance economic premium ratios are significantly larger than the liability insurance ratios, reflecting the higher underwriting risk of property insurance.
For the average firm in the sample, the liability insurance allocated surplus to liability ratio is higher than the corresponding ratio for the property lines. This is contrary to the industry-wide results shown in Table 4. The reason is that for many companies, property lines represent only a small proportion of their total business. Even though such lines have undesirable covariance properties, they are valuable for diversification as long as they represent only a small proportion of the portfolio. Thus, in averaging across the companies in the sample, the surplus allocation is lower for property lines than for liability lines.

The traded firm summary statistics in Table 5 also show that the property insurance economic premium ratio exceeds the liability insurance economic premium ratio. The traded firms (Table 5) are significantly larger on average than the firms in the overall sample (Table 4). However, much of this is due to the fact that the traded firm data are on an insurance group basis, while the overall sample is at the company level. On average, the insolvency put per dollar of liabilities is about 1.1%. This is the same order of magnitude as the insolvency rate among property-liability insurers during the period 1993-2002 (Hartwig 2004).

**Univariate Results**

We begin investigating the primary hypotheses by first conducting a set of univariate tests. As a first look at the relationship between insurer insolvency risk and the price of insurance, the average economic premium ratios for property and liability insurance are plotted in Figure 1 as functions of the A.M. Best ratings for the firms in the sample. It is clear from the figure that firms with relatively high ratings command higher prices. The average EPR across the entire sample for the property(liability) line of insurance for the highest rated insurers averages is 1.23(1.13) while lower rated insurers have lower average EPRs. For example, B and B- insurers have an average EPR of only 1.09(0.99). The difference for the B rated insurers and lower are statistically significant at reasonable levels. Clearly insurers with ratings of A++ through B+ command the highest prices and the lowest are for firms with ratings below B.
The data in Figure 2 were generated by splitting the insurers in our data set into deciles based upon the overall capital-to-liability ratio of the firms. The chart plots the upper limit of the capital-to-liability deciles along the x-axis (in log scale) and y-axis shows the average EPR for each line of insurance across the insurers in that decile. Consistent with hypothesis 1, insurers with greater capitalization command higher prices in the marketplace.

The data in Figure 3 is similar to Figure 2 except this time we divide the insurers into deciles based upon the line specific capitalization ratios relative to the firm’s overall capitalization ratio. Insurers located in the lower deciles are writing business which contributes only a small amount towards the overall risk of the firm. Therefore, insurers can allocate only a small portion of their risk capital charges to these lines. However, insurers located in the upper deciles are writing business where the relative riskiness of that line of insurance is greater than the overall risk of the insurer as a whole. Therefore these lines of insurance will command a greater proportion of the risk capital charges than the is the percentage of the firm’s liabilities. The results strongly suggest that insurers recognize these relative risk concentrations and adjust prices according.

**Regression Results**

The regression results for property insurance based on the overall sample are presented in Table 6. Several specifications are presented, with different variables included to measure the effects of capital allocation and with the company and year fixed effects included and excluded. We focus most of the discussion on the regressions that include both company and year fixed effects (the last three columns in the table), which we consider to be the most reliable.

The results in Table 6 provide strong support for Hypothesis 1, that the price of insurance is inversely related to insolvency risk. Three variables are included in the regressions for A.M. Best financial ratings – indicator variables set equal to 1 for firms with Best’s ratings of A or A-, B++ or B+, and B or lower, respectively, and set equal to zero otherwise. The omitted category consists of insurers with Best’s ratings of A++ or A+. Consistent with Hypothesis 1, the coefficients of the
Best’s rating variables are negative in all specifications of the model, and they are all statistically significant in the equations with full fixed effects. Moreover, in the full fixed effects models, the coefficients of the Best’s rating variables become monotonically smaller as the rating categories decline, as expected if progressively lower ratings are associated with higher insolvency risk. Further support for Hypothesis 1 is provided by the equations that include the firm’s overall capital to liability ratio. In these equations, the capital to liability ratio has a significant positive coefficient, as expected if higher capitalization is associated with lower insolvency risk.

The results in Table 6 also provide support for Hypothesis 2, that the price of insurance is directly related to the amount of capital allocated to the line. In two of the three equations that include the property insurance Myers-Read allocated-surplus to liability ratio, this variable is positive and statistically significant. However, the surplus to liability ratio is negative and not statistically significant in the equation that includes full fixed effects. Thus, based on this variable taken alone, there is mixed support for Hypothesis 2. We provide further evidence on Hypothesis 2 by including the ratio of the property insurance surplus-to-liability ratio to the overall firm surplus-to-liability ratio. The rationale is that if the property line consumes relatively more surplus than average for a given company, the property insurance EPR should be higher, other things equal. The coefficient of this variable is statistically significant and positive in all regressions where it is included, supporting Hypothesis 2. Additional regressions, not shown in the table, provide support for Hypothesis 3, that, controlling for overall insolvency risk, the price of insurance is directly related to the covariability of the firm’s overall liability portfolio.

The coefficients of the control variables in the property insurance regressions shown in Table 6 are mostly consistent with expectations, although few of them are statistically significant in the full fixed effects models. The property insurance liability growth rate is negative and significant, providing evidence that the positive effect of the growth rate on the insolvency put option is dominant over its effect in terms of discounting the put value. The log of assets is negative in all
specifications, as expected if larger firms are more diversified and hence have lower risk aversion, other things equal. However, this variable is not significant in the full fixed effects models. The single firm indicator is positive in all regressions, consistent with the argument that unaffiliated firms sacrifice a source of diversification and hence tend to be more risk averse. The indicator variable for membership in a publicly traded insurance group is negative in all regressions and statistically significant in the full fixed effects regressions, consistent with the argument that traded firms tend to be less risk averse because they have better access to capital. The mutual dummy variable is negative and significant except in the full fixed effects models, where it is positive and insignificant. Hence, there is some evidence that mutuals have lower prices, perhaps because they tend to focus on less complex and less risky business.

The liability insurance EPR regressions for the overall sample, presented in Table 7, also provide support for Hypothesis 1. The A.M. Best ratings variables are negative in all specifications tested and generally display a monotonic inverse relationship between the coefficients and progressively lower rating categories. However, the results are weaker than for the property lines in the sense that the coefficients of the (A or A-) and the (B++ or B+) dummies are not statistically significant in the full fixed effects models. However, the overall firm capital-to-liability ratio is significant in all three regressions where it was included, providing further support for Hypothesis 1. The liability insurance EPR regressions also provide strong support for Hypothesis 2. Both the liability insurance allocated-capital to liabilities ratio and the ratio of the liability capital-to-liabilities ratio to the overall firm capital-to-liabilities ratio are statistically significant and positive in all of the models where they appear. In regressions not shown in the table, we also find support for Hypothesis 3, based on positive and significant coefficients on the covariance of the liability insurance line with the firm’s overall liability portfolio.

The results with the control variables in the overall sample liability insurance EPR regressions in Table 7 are mostly consistent with the property insurance EPR regressions shown in
Table 7. An exception is the log of assets, which is positive and significant in two of the three full fixed effects models, suggesting that larger firms may command higher prices in the liability insurance market. This perhaps could suggest that larger firms have an advantage in managing long-tail liability claims runoff operations. The percentage of premiums in price regulated lines is negative and significant, as expected if regulation leads to price suppression.

The property insurance EPR regressions for the publicly traded firms are shown in Table 8. The regressions provide only minimal support for Hypothesis 1 as the market value insolvency put variable is not statistically significant in any of the models. However, the overall capital-to-liability ratio is statistically significant and positive in the full fixed effects models. Thus, Hypothesis 1 is supported, but the results are somewhat weaker than in the overall firm sample. The regressions in Table 8 also provide only mixed support for Hypothesis 2. Both the property insurance allocated capital to liabilities ratio and the ratio of the property insurance capital ratio to the overall firm capital ratio are significant and positive in all specifications where they appear except the relative capitalization ratios in the full effects models. Likewise, in regressions not shown in the table, the covariance of the property insurance line with the firm’s overall liability portfolio is positive and statistically significant, supporting Hypothesis 3.

The coefficients of the control variables in the Table 8 regressions are mostly consistent with expectations. The property insurance liability growth rate is negative and significant in the fully specified models as is the percentage of expenses allocated to advertising.

The liability insurance EPR regressions for the publicly traded firms are shown in Table 9. The results in Table 9 are, in general, stronger than those shown for the property lines of insurance in Table 8. The market-based financial strength proxy is now negative and significant in the fully specified models suggesting the market-based measure of default is correlated with the price of liability insurance. In addition, the coefficients on the overall capitalization and on the line-specific capitalization ratios are also significant in the fully specific models. Thus, we find strong support
from the publicly traded liability insurers for all three hypotheses.

5. Conclusions

Recent theoretical research suggests that prices for illiquid, intermediated risks will not be independent of the characteristics of the intermediary but rather will reflect firm capital structure and risk aversion. In particular, prices of non-tradeable intermediated risks are predicted to vary positively with the covariance of a risk with the firm’s other projects and with the amount of capital allocated to a given project or line of business. Based on earlier research, prices of intermediated risks also are predicted to be inversely related to the intermediary’s insolvency risk. This paper provides empirical tests of these hypotheses using two samples of U.S. property-liability insurers over the sample period 1997-2002 – an overall sample consisting of all insurers with usable data reporting to the National Association of Insurance Commissioners and a sample consisting of publicly traded insurers.

To test the hypotheses, we conduct regressions where the dependent variable is the economic premium ratio, defined as the premiums for a given line of insurance divided by the present value of incurred losses for the line. To test the hypothesis that prices are inversely related to insolvency risk, we include as explanatory variables in the regressions the estimated overall insolvency put value as a proportion of firm liabilities and alternatively test the A.M. Best ratings of the firms in the sample. The results are consistent with the hypothesis – the insolvency put is inversely related to price in most models tested and firms with lower Best’s ratings have significantly lower prices.

We allocate capital by line of insurance using the methodology proposed in Myers-Read (2001), where capital is allocated by taking the derivative of a firm’s insolvency put value with respect to the present value of loss liabilities for each line. In our capital allocations, we set the derivatives equal across lines, implying that each line of business has the same marginal impact on the insolvency put. The resulting capital allocations per dollar of liabilities are then included in the regression analysis. The results provide strong support for the hypothesis that prices are directly
related to capital allocations. Finally, we test the hypothesis that prices for intermediated products are positively related to the covariability of a product with the firm’s overall portfolio by including the covariance of the loss ratio for a given line of insurance with the insurer’s overall liability portfolio. The results provide support for the covariability hypothesis.

In general, this paper provides strong evidence supporting theoretical propositions that the prices of illiquid, intermediated risks depend upon firm capital structure and risk aversion. Thus, the presence of costly capital and non-tradeability of many intermediated risks implies that prices depend upon risks that are non-systematic in the context of perfect markets asset pricing theory. This represents a market imperfection that limits the ability of intermediated markets to manage and diversify risk. With advances in information technology, it is possible that securitization will enable intermediaries to move assets and liabilities off-balance-sheet, creating markets in securitized risk products. Indeed, this has already begun to happen with the emergence of catastrophic loss securities and asset-backed securities for life insurance assets and liabilities. As this process continues, the prices of intermediated risks amenable to securitization can be expected to converge to the prices implied by asset pricing theory, reducing the costs of risk management in the economy.
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Table 1

Table displays the balance sheet for the U.S. property-liability insurance industry where the assets and liabilities have been adjusted to market values. All assets values have been adjusted to reflect market values using statutory accounting principles. The insurance reserves are reported after discounting the expected future loss cash flows for each line of insurance using the U.S. Treasury spot-rate term yield curve. The liability class “Other Liabilities” equals the total liabilities of the industry net of the reserves for property lines of insurance and for liability lines of insurance after discounting. Source: A.M. Best (2001)

<table>
<thead>
<tr>
<th>Economic Assets</th>
<th>Amount (millions)</th>
<th>Percentage</th>
<th>Economic Liabilities and Equity</th>
<th>Amount (millions)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stocks</td>
<td>$267,651</td>
<td>23.83%</td>
<td>Reserves for Property Lines</td>
<td>$99,685</td>
<td>15.99%</td>
</tr>
<tr>
<td>Government Bonds</td>
<td>$343,562</td>
<td>30.59%</td>
<td>Reserves for Liability Lines</td>
<td>$348,424</td>
<td>55.88%</td>
</tr>
<tr>
<td>Corporate Bonds</td>
<td>$177,461</td>
<td>15.80%</td>
<td>Other Liabilities</td>
<td>$175,464</td>
<td>28.14%</td>
</tr>
<tr>
<td>Real Estate</td>
<td>$9,646</td>
<td>0.86%</td>
<td>Economic Liabilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mortgages</td>
<td>$1,646</td>
<td>0.15%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash + Other Inv.</td>
<td>$74,194</td>
<td>6.61%</td>
<td>Economic Equity</td>
<td>$499,413</td>
<td></td>
</tr>
<tr>
<td>Other Assets</td>
<td>$248,826</td>
<td>22.16%</td>
<td>Economic Liabilities &amp; Equity</td>
<td>$1,122,987</td>
<td></td>
</tr>
<tr>
<td>Economic Assets</td>
<td>$1,122,987</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The table displays standard deviation and correlation statistics of the quarterly time series of returns of various asset classes and of the underwriting returns for two aggregated lines of insurance: property lines and liability lines. The underwriting returns are calculated as the natural logarithm of the present value of the losses incurred during the quarter relative to the premiums earned during the same quarter. Spot-rate treasury yield curves are used to discount the losses. The expected future loss cash flows are estimated using payout patterns based upon industry aggregate data and the Taylor Separation Method (Taylor 2000). The quarterly underwriting returns were adjusted for seasonality using the U.S. Census Bureau's X11 procedure before we calculated the summary statistics reported below. The return for the liability class labeled "Other Liabilities" equals the natural logarithm of the gross quarterly percentage change in the total liabilities of the insurance industry net of the present value of the insurance reserves. The time period begins in the first quarter of 1991 and ends in the fourth quarter of 2002.

### Liability Class

<table>
<thead>
<tr>
<th>Liability Class</th>
<th>Volatility</th>
<th>Liability Correlation Matrix</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property Lines</td>
<td>18.00%</td>
<td>100.0%</td>
<td>42.8% -11.1% NAIC and author's calculation</td>
</tr>
<tr>
<td>Liability Lines</td>
<td>13.25%</td>
<td>100.0%</td>
<td>6.4% NAIC and author's calculation</td>
</tr>
<tr>
<td>Other Liabilities</td>
<td>4.91%</td>
<td>100.0%</td>
<td>NAIC and author's calculation</td>
</tr>
</tbody>
</table>

### Asset/Liability Correlation Matrix

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>Annual Volatility</th>
<th>Short-tail Lines</th>
<th>Long-tail Liability</th>
<th>Other Liabilities</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stocks</td>
<td>12.74%</td>
<td>-43.5%</td>
<td>-39.0%</td>
<td>-26.0%</td>
<td>S&amp;P 500</td>
</tr>
<tr>
<td>Government Bonds</td>
<td>3.00%</td>
<td>6.1%</td>
<td>23.3%</td>
<td>5.8%</td>
<td>Lehman Brothers Int. Term Total Return</td>
</tr>
<tr>
<td>Corporate Bonds</td>
<td>7.18%</td>
<td>-39.8%</td>
<td>-12.7%</td>
<td>-5.0%</td>
<td>Moody's Corp. Bond Total Return</td>
</tr>
<tr>
<td>Real Estate</td>
<td>9.23%</td>
<td>-12.6%</td>
<td>12.1%</td>
<td>5.6%</td>
<td>NAREIT Total Return</td>
</tr>
<tr>
<td>Mortgages</td>
<td>2.82%</td>
<td>-1.7%</td>
<td>16.4%</td>
<td>-0.2%</td>
<td>Merrill Lynch MBS Total Return</td>
</tr>
<tr>
<td>Cash + Other Inv.</td>
<td>0.43%</td>
<td>-2.1%</td>
<td>-47.4%</td>
<td>-8.5%</td>
<td>30-day Treasury Bill</td>
</tr>
<tr>
<td>Other Assets</td>
<td>5.70%</td>
<td>12.8%</td>
<td>24.5%</td>
<td>79.8%</td>
<td>NAIC and author's calculation</td>
</tr>
</tbody>
</table>

Table 2
The table shows the marginal capital requirements and the allocation of the equity capital across three lines of insurance using the approach of Myers and Read (2001). The column labelled "Capital-to-Liability Ratio" displays the line specific marginal capital requirement per $1 of liability in that line of insurance. The column labeled "Relative Capital-to-Liability Ratio" displays the marginal capital requirement for the line of insurance relative to the overall industry capital-to-liability ratio which equaled 80.1% in 2000.

<table>
<thead>
<tr>
<th>Line</th>
<th>Capital - to - Liability Ratio</th>
<th>Capital-to-Liability Ratio</th>
<th>Allocated Capital (millions)</th>
<th>% of Industry Capital</th>
<th>% of Industry Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property Lines</td>
<td>118.1%</td>
<td>1.475</td>
<td>$ 117,743</td>
<td>23.6%</td>
<td>16.0%</td>
</tr>
<tr>
<td>Liability Lines</td>
<td>110.6%</td>
<td>1.381</td>
<td>$ 385,505</td>
<td>77.2%</td>
<td>55.9%</td>
</tr>
<tr>
<td>Other Liabilities</td>
<td>-2.2%</td>
<td>-2.7%</td>
<td>$ (3,835)</td>
<td>-0.8%</td>
<td>28.1%</td>
</tr>
</tbody>
</table>
Table 4: Summary Statistics All Insurers: 1997-2002

Table displays summary statistics of variables used in the empirical tests. The line-specific economic premium ratio equals the accident year net premiums written in the line of insurance minus the underwriting expenses divided by the present value of the net losses incurred during the accident year minus policyholder dividends paid. The liability growth rates for each line grouping were estimated as the weighted average growth rate of the total industry losses incurred for each line of insurance that makes up the line grouping weighted by the proportion of the net premium written by the individual insurer in each line of insurance. The growth rates were calculated using the previous five years of data. The line specific capital-liability ratios were calculated using the marginal capital allocation approach of Myers and Read (2001). Each relative capital-liability ratio equals the line specific marginal capital requirements per $1 of liability relative to the overall capital-liability ratio. The percent of premiums in price regulated lines of insurance equals the proportion of the insurer’s total net premiums written in private passenger automobile liability and in workers’ compensation insurance. We exclude observations when the economic premium ratio is greater than 5 or less than 0.20. We also exclude observations when either the overall firm capital-liability ratio is greater than 5 or less than 0.20 or when the line specific relative capital-liability ratio is greater than 5 or less than 0.20.

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Mean</th>
<th>Std Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liability Line Economic Premium Ratio</td>
<td>1.080</td>
<td>0.344</td>
<td>0.202</td>
<td>4.922</td>
</tr>
<tr>
<td>Property Line Economic Premium Ratio</td>
<td>1.206</td>
<td>0.525</td>
<td>0.203</td>
<td>4.898</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Mean</th>
<th>Std Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Assets (000’s)</td>
<td>$ 758,242</td>
<td>$ 3,243,333</td>
<td>$ 1,077</td>
<td>$80,114,034</td>
</tr>
<tr>
<td>Total Liabilities (000’s)</td>
<td>$ 485,674</td>
<td>$ 1,887,761</td>
<td>$ 345</td>
<td>$34,472,355</td>
</tr>
<tr>
<td>Equity Capital (000’s)</td>
<td>$ 272,568</td>
<td>$ 1,467,581</td>
<td>$ 732</td>
<td>$45,762,499</td>
</tr>
<tr>
<td>Asset-to Liability Ratio</td>
<td>1.765</td>
<td>0.573</td>
<td>1.149</td>
<td>4.784</td>
</tr>
<tr>
<td>Property Line Loss Growth Rate</td>
<td>1.37%</td>
<td>1.76%</td>
<td>-9.12%</td>
<td>12.94%</td>
</tr>
<tr>
<td>Liability Line Loss Growth Rate</td>
<td>2.06%</td>
<td>1.32%</td>
<td>-6.40%</td>
<td>12.27%</td>
</tr>
<tr>
<td>Liability Line Capital-Liability Ratio</td>
<td>1.310</td>
<td>1.202</td>
<td>0.107</td>
<td>13.332</td>
</tr>
<tr>
<td>Property Line Line Capital-Liability Ratio</td>
<td>1.181</td>
<td>1.154</td>
<td>0.112</td>
<td>17.957</td>
</tr>
<tr>
<td>Overall Firm Capital-Liability Ratio</td>
<td>1.005</td>
<td>0.746</td>
<td>0.201</td>
<td>4.982</td>
</tr>
<tr>
<td>Relative Liability Line Capital-Liability Ratio</td>
<td>1.275</td>
<td>0.357</td>
<td>0.267</td>
<td>4.301</td>
</tr>
<tr>
<td>Relative Property Line Capital-Liability Ratio</td>
<td>1.138</td>
<td>0.401</td>
<td>0.208</td>
<td>4.576</td>
</tr>
<tr>
<td>Percent Premiums in Price Regulated Lines</td>
<td>30.80%</td>
<td>21.92%</td>
<td>0.00%</td>
<td>96.65%</td>
</tr>
<tr>
<td>Advertisement Exp. to Total Exp. Ratio</td>
<td>0.97%</td>
<td>2.63%</td>
<td>0.00%</td>
<td>81.31%</td>
</tr>
<tr>
<td>Indicator if firm is member of a publicly traded group</td>
<td>0.272</td>
<td>0.445</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Indicator if firm is member of a mutual group</td>
<td>0.365</td>
<td>0.482</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Single Firm Indicator</td>
<td>0.189</td>
<td>0.391</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Indicator if firm's A.M. Best Rating is A++ or A+</td>
<td>0.295</td>
<td>0.456</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Indicator if firm's A.M. Best Rating is A or A-</td>
<td>0.507</td>
<td>0.500</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Indicator if firm's A.M. Best Rating is B++ or B+</td>
<td>0.136</td>
<td>0.342</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Indicator if firm's A.M. Best Rating is B or B-</td>
<td>0.049</td>
<td>0.216</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Indicator if firm's A.M. Best Rating is C++ or C+</td>
<td>0.009</td>
<td>0.092</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Indicator if firm's A.M. Best Rating is C or C-</td>
<td>0.002</td>
<td>0.049</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Indicator if firm's A.M. Best Rating is D</td>
<td>0.002</td>
<td>0.046</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Indicator if firm's A.M. Best Rating is E or F</td>
<td>0.001</td>
<td>0.025</td>
<td>0.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Note - 6218 Observations
### Table 5: Summary Statistics All Insurers: 1997-2002

Table displays summary statistics of variables used in the empirical tests based upon publicly traded insurers only. The line-specific economic premium ratio equals the accident year net premiums written in the line of insurance minus the underwriting expenses divided by the present value of the net losses incurred during the accident year minus policyholder dividends paid. The liability growth rates for each line grouping were estimated as the weighted average growth rate of the total industry losses incurred for each line of insurance that makes up the line grouping weighted by the proportion of the net premium written by the individual insurer in each line of insurance. The growth rates were calculated using the previous five years of data. The line specific capital-liability ratios were calculated using the marginal capital allocation approach of Myers and Read (2001). Each relative capital-liability ratio equals the line specific marginal capital requirements per $1 of liability relative to the overall capital-liability ratio. The percent of premiums in price regulated lines of insurance equals the proportion of the insurer's total net premiums written in private passenger automobile liability and in workers' compensation insurance. The insolvency put variable per $1 of liability was calculated after solving for the market value of the assets and the implied volatility of the asset process, equations (6) and (7). We exclude observations when the economic premium ratio is greater than 5 or less than 0.20. We also exclude observations when either the overall firm capital-liability ratio is greater than 5 or less than 0.20 or when the line specific relative capital-liability ratio is greater than 5 or less than 0.20.

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Mean</th>
<th>Std Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liability Line Economic Premium Ratio</td>
<td>1.027</td>
<td>0.275</td>
<td>0.037</td>
<td>2.824</td>
</tr>
<tr>
<td>Property Line Economic Premium Ratio</td>
<td>1.183</td>
<td>0.419</td>
<td>0.051</td>
<td>3.318</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Explantory Variables and Inputs for Insolvency Put Valuation</th>
<th>Mean</th>
<th>Std Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Assets (000's)</td>
<td>$19,427,237</td>
<td>$57,392,429</td>
<td>$26,104</td>
<td>$561,229,193</td>
</tr>
<tr>
<td>Total Liabilities (000's)</td>
<td>$15,973,364</td>
<td>$50,025,657</td>
<td>$18,187</td>
<td>$498,393,226</td>
</tr>
<tr>
<td>Asset-to Liability Ratio</td>
<td>1.442</td>
<td>0.337</td>
<td>1.045</td>
<td>4.479</td>
</tr>
<tr>
<td>Market Capitalization (000's)</td>
<td>$6,806,242</td>
<td>$24,869,374</td>
<td>$3,200</td>
<td>$229,918,000</td>
</tr>
<tr>
<td>Property Line Loss Growth Rate</td>
<td>1.75%</td>
<td>2.02%</td>
<td>-6.46%</td>
<td>13.03%</td>
</tr>
<tr>
<td>Liability Line Loss Growth Rate</td>
<td>2.24%</td>
<td>1.44%</td>
<td>-2.44%</td>
<td>10.74%</td>
</tr>
<tr>
<td>Net Interest Rate</td>
<td>1.57%</td>
<td>2.89%</td>
<td>-8.58%</td>
<td>7.89%</td>
</tr>
<tr>
<td>Annualized St.Dev of Equity Returns Based on Daily Data</td>
<td>44.28%</td>
<td>30.32%</td>
<td>12.43%</td>
<td>282.28%</td>
</tr>
<tr>
<td>Implied Volatility of Firm</td>
<td>14.68%</td>
<td>17.66%</td>
<td>1.51%</td>
<td>203.65%</td>
</tr>
<tr>
<td>Insolvency Put (000's)</td>
<td>$2,486</td>
<td>$10,361</td>
<td>$-</td>
<td>$127,835</td>
</tr>
<tr>
<td>Insolvency Put per Liabilities</td>
<td>0.011</td>
<td>0.069</td>
<td>-</td>
<td>0.831</td>
</tr>
<tr>
<td>Market Value of Assets (000's)</td>
<td>$22,660,481</td>
<td>$71,742,148</td>
<td>$14,322</td>
<td>$666,353,031</td>
</tr>
<tr>
<td>Market Value Asset-to-Liability Ratio</td>
<td>1.554</td>
<td>0.545</td>
<td>0.256</td>
<td>4.262</td>
</tr>
<tr>
<td>Liability Line Capital-Liability Ratio</td>
<td>1.167</td>
<td>0.883</td>
<td>0.255</td>
<td>6.651</td>
</tr>
<tr>
<td>Property Line Capital-Liability Ratio</td>
<td>0.936</td>
<td>0.718</td>
<td>0.230</td>
<td>4.545</td>
</tr>
<tr>
<td>Overall Firm Capital-Liability Ratio</td>
<td>0.908</td>
<td>0.583</td>
<td>0.242</td>
<td>4.912</td>
</tr>
<tr>
<td>Relative Liability Line Capital-Liability Ratio</td>
<td>1.264</td>
<td>0.224</td>
<td>0.480</td>
<td>2.483</td>
</tr>
<tr>
<td>Relative Property Line Capital-Liability Ratio</td>
<td>1.013</td>
<td>0.319</td>
<td>0.585</td>
<td>3.170</td>
</tr>
<tr>
<td>Advertisement Exp. to Total Exp. Ratio</td>
<td>0.008</td>
<td>0.014</td>
<td>-</td>
<td>0.105</td>
</tr>
<tr>
<td>Percent Premiums in Price Regulated Lines</td>
<td>28.81%</td>
<td>19.47%</td>
<td>0.00%</td>
<td>92.29%</td>
</tr>
</tbody>
</table>

Note - 347 Observations
### Table 6
Regressions Results Property Lines of Insurance: 1997 - 2002

Table displays results of the following cross-sectional time-series regression:

\[
\text{Property EPR}_{it} = \alpha + \theta \text{A.M.Best}_{it} + \beta_1 \frac{s_{it}}{s_{it-1}} + \beta_2 \text{X}_i + \gamma' \text{X}_i + \eta_i + \epsilon_{it}
\]

where Property EPR\(_{it}\) equals insurer i's premiums written net of underwriting expenses in property lines of insurance in year t divided by the present value of losses incurred net policyholder dividends paid in year t. A.M.Best\(_{it}\) is a vector of indicator variables used to identify the A.M.Best financial strength rating for insurer i in year t. \(\frac{s_{it}}{s_{it-1}}\) is insurer i’s marginal capital requirement for the property line of insurance, \(s_{it}\), relative to the insurer's overall capital-liability ratio in year t, \(s\). X is a vector of control variables. The regression is estimated using ordinary least squares with and without controlling for year and company fixed effects.

<table>
<thead>
<tr>
<th>Year Fixed Effects</th>
<th>No</th>
<th>No</th>
<th>No</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company Fixed Effects</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>(\beta_1)</th>
<th>(\beta_2)</th>
<th>(\gamma')</th>
<th>(\epsilon_{it})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.514 ***</td>
<td>(15.290)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Property Line Line Capital-Liability Ratio</td>
<td>0.045 ***</td>
<td>(8.360)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Relative Property Line Line Capital-Liability Ratio</td>
<td>-</td>
<td>(6.820)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Overall Firm Capital-Liability Ratio</td>
<td>-</td>
<td>(7.100)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indicator if firm's A.M. Best Rating is A or A-</td>
<td>-0.026</td>
<td>(1.490)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indicator if firm's A.M. Best Rating is B++ or B+</td>
<td>-0.240 ***</td>
<td>(7.100)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indicator if firm's A.M. Best Rating is B or lower</td>
<td>-0.654 *</td>
<td>(1.810)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Property Line Loss Growth Rate</td>
<td>-0.016 ***</td>
<td>(3.240)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Log(Book Value of Assets)</td>
<td>-0.166</td>
<td>(0.730)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Advertisement Exp. to Total Exp. Ratio</td>
<td>-0.007</td>
<td>(0.420)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Single Firm Indicator</td>
<td>0.096 ***</td>
<td>(4.890)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indicator if firm is member of a publicly traded group</td>
<td>-0.075 ***</td>
<td>(4.970)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indicator if firm is member of a mutual group</td>
<td>-0.087 ***</td>
<td>(5.000)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

\(R^2\): 3.23% 2.89% 3.31% 3.96% 3.54% 4.01% 51.50% 51.62% 51.65%

Note: t-statistics are reported in parantheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent p-values, respectively. 6959 observations.
### Table 7
Regressions Results Liability Lines of Insurance: 1997 - 2002

Table displays results of the following cross-sectional time-series regression:

$$\text{Liability EPR}_{it} = \alpha + \theta' \text{A.M.Best}_{it} + \beta \frac{s_{li}}{s_{it}} + \gamma' X + \nu_{it} + \eta + \xi$$

where Liability EPR$_{it}$ equals insurer i's premiums written net of underwriting expenses in property lines of insurance in year t divided by the present value of losses incurred net policyholder dividends paid in year t. A.M.Best$_{it}$ is a vector of indicator variables used to identify the A.M.Best financial strength rating for insurer i in year t. $\frac{s_{li}}{s_{it}}$ is insurer i's marginal capital requirement for the liability line of insurance, s$_{li}$, relative to the insurer's overall capital-liability ratio in year t. X is a vector of control variables. The regression is estimated using ordinary least squares with and without controlling for year and company fixed effects.

<table>
<thead>
<tr>
<th>Year Fixed Effects</th>
<th>Company Fixed Effects</th>
<th>No</th>
<th>No</th>
<th>No</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td></td>
<td>1.596 ***</td>
<td>1.671 ***</td>
<td>1.448 ***</td>
<td>1.633 ***</td>
<td>1.472 ***</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Liability Line Capital-Liability Ratio</td>
<td>0.043 ***</td>
<td>(9.890)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relative Liability Line Capital-Liability Ratio</td>
<td>0.101 ***</td>
<td>(7.820)</td>
<td>0.103 ***</td>
<td>(8.010)</td>
<td>0.104 ***</td>
<td>(8.000)</td>
<td>0.126 ***</td>
<td>(6.260)</td>
<td>0.129 ***</td>
</tr>
<tr>
<td></td>
<td>Overall Firm Capital-Liability Ratio</td>
<td>-</td>
<td>-</td>
<td>0.051 ***</td>
<td>(6.090)</td>
<td>-</td>
<td>-</td>
<td>0.052 ***</td>
<td>(8.250)</td>
<td>-</td>
</tr>
</tbody>
</table>
| Indicator if firm's A.M. Best Rating is A or A- | -0.044 *** | (3.810) | -0.047 *** | (4.020) | -0.040 *** | (4.040) | -0.049 *** | (4.170) | -0.042 *** | (3.990) | -0.041 *** | (0.720) | -0.014 | (0.720) | -0.014 | (0.690)
| Indicator if firm's A.M. Best Rating is B++ or B+ | -0.104 *** | (6.310) | -0.119 *** | (7.270) | -0.098 *** | (5.980) | -0.114 *** | (6.350) | -0.098 *** | (7.270) | -0.094 *** | (5.990) | -0.042 | (1.410) | -0.048 | (1.480)
| Indicator if firm's A.M. Best Rating is B or lower | -0.213 *** | (9.600) | -0.239 *** | (10.870) | -0.208 *** | (9.380) | -0.215 *** | (9.690) | -0.240 *** | (10.920) | -0.209 *** | (9.430) | -0.178 *** | (4.670) | -0.199 *** | (5.250) | -0.187 *** | (4.890)
| Liability Line Loss Growth Rate | -1.542 *** | (5.800) | -1.665 *** | (6.230) | -1.641 *** | (6.170) | -1.532 *** | (5.280) | -1.495 *** | (5.140) | -1.534 *** | (5.300) | -2.300 *** | (6.060) | -2.303 *** | (6.070) | -2.288 *** | (6.030)
| Log(Book Value of Assets) | -0.021 *** | (6.680) | -0.029 *** | (9.350) | -0.020 *** | (6.300) | -0.021 *** | (6.690) | -0.029 *** | (9.370) | -0.020 *** | (6.290) | 0.068 *** | (3.570) | 0.027 | (1.440) | 0.042 | (2.150)
| Advertisement Exp. to Total Exp. Ratio | 0.450 *** | (2.880) | 0.430 *** | (2.740) | 0.408 *** | (2.610) | 0.481 *** | (3.070) | 0.449 *** | (2.860) | 0.433 *** | (2.860) | -0.246 | (1.000) | -0.228 | (0.930) | -0.254 | (1.030)
| Percent Premiums in Price Regulated Lines | -0.122 *** | (7.050) | -0.147 *** | (8.410) | -0.130 *** | (7.440) | -0.128 *** | (7.380) | -0.152 *** | (8.710) | -0.136 *** | (7.760) | -0.200 *** | (3.760) | -0.214 *** | (4.010) | -0.210 *** | (3.940)
| Single Firm Indicator | 0.032 *** | (2.690) | 0.040 *** | (3.330) | 0.036 *** | (2.950) | 0.032 *** | (2.670) | 0.040 *** | (3.310) | 0.035 *** | (2.920) | -0.025 | (0.850) | -0.023 | (0.780) | -0.023 | (0.790)
| Indicator if firm is member of a publicly traded group | -0.027 ** | (2.330) | -0.029 ** | (2.490) | -0.028 ** | (2.440) | -0.025 ** | (2.200) | -0.027 ** | (2.230) | -0.026 ** | (2.290) | -0.068 *** | (2.780) | -0.062 ** | (2.550) | -0.066 ** | (2.700)
| Indicator if firm is member of a mutual group | -0.094 *** | (9.720) | -0.089 *** | (9.180) | -0.091 *** | (9.390) | -0.093 *** | (9.620) | -0.088 *** | (8.990) | -0.090 *** | (9.240) | 0.041 | (1.140) | 0.044 | (1.230) | 0.042 | (1.180)

| R² | 5.83% | 5.45% | 6.21% | 6.37% | 5.96% | 6.75% | 49.13% | 49.20% | 49.27% |

Note: t-statistics are reported in parantheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent p-values, respectively. 8010 observations
Table 8
Regressions Results Property Lines of Insurance for Publicly Traded Insurers: 1997 - 2002

Table displays results of the following cross-sectional time-series regression:

\[ \text{Property EPR}_{it} = \alpha + \theta \frac{\text{Ins Put}_{it}}{\text{Liabilities}_{it}} + \beta \frac{s_{it}}{s_{0t}} + \gamma X + \nu_{i} + \eta_{t} + \epsilon_{it} \]

where \( \text{Property EPR}_{it} \) equals insurer \( i \)'s premiums written net of underwriting expenses in property lines of insurance in year \( t \) divided by the present value of losses incurred net policyholder dividends paid in year \( t \). The insolvency put value relative to total liabilities is used to proxy for the financial strength of the insurer \( i \) in year \( t \). \( s_{it} \) is insurer \( i \)'s marginal capital requirement for the property line of insurance, relative to the insurer's overall capital-liability ratio in year \( t \), \( s_{0t} \). \( X \) is a vector of control variables. The regression is estimated using ordinary least squares with and without controlling for year and company fixed effects.

<table>
<thead>
<tr>
<th>Year Fixed Effects</th>
<th>No</th>
<th>No</th>
<th>No</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>1.241 ***</td>
<td>1.207 ***</td>
<td>1.099 ***</td>
<td>1.337 ***</td>
<td>1.261 ***</td>
<td>1.174 ***</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(6.120)</td>
<td>(5.980)</td>
<td>(5.100)</td>
<td>(6.330)</td>
<td>(5.910)</td>
<td>(5.280)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property Line Line Capital-Liability Ratio</td>
<td>0.084 ***</td>
<td>-</td>
<td>-</td>
<td>0.087 ***</td>
<td>-</td>
<td>-</td>
<td>0.179 ***</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(2.740)</td>
<td>(2.870)</td>
<td>(2.690)</td>
<td>(2.740)</td>
<td>(2.870)</td>
<td>(2.690)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Property Line Line Capital-Liability Ratio</td>
<td>0.225 ***</td>
<td>0.217 ***</td>
<td>-</td>
<td>0.242 ***</td>
<td>0.232 ***</td>
<td>-</td>
<td>0.104</td>
<td>0.169</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.220)</td>
<td>(3.100)</td>
<td>(3.500)</td>
<td>(3.330)</td>
<td>(3.300)</td>
<td>(3.820)</td>
<td>(1.300)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Firm Capital-Liability Ratio</td>
<td>-</td>
<td>-</td>
<td>0.061</td>
<td>-</td>
<td>-</td>
<td>0.060</td>
<td>-</td>
<td>-</td>
<td>0.188 **</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>(1.420)</td>
<td>-</td>
<td>-</td>
<td>(1.390)</td>
<td>-</td>
<td>-</td>
<td>(2.450)</td>
</tr>
<tr>
<td>Insolvency Put per Liabilities</td>
<td>0.613</td>
<td>0.373</td>
<td>0.459</td>
<td>0.706</td>
<td>0.463</td>
<td>0.544</td>
<td>0.017</td>
<td>0.059</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(1.230)</td>
<td>(0.750)</td>
<td>(0.920)</td>
<td>(1.440)</td>
<td>(0.950)</td>
<td>(1.110)</td>
<td>(0.030)</td>
<td>(0.110)</td>
<td>(0.007)</td>
</tr>
<tr>
<td>Property Line Loss Growth Rate</td>
<td>-1.036</td>
<td>-1.406</td>
<td>-1.415</td>
<td>-1.406</td>
<td>-1.583</td>
<td>-1.714</td>
<td>-4.373 ***</td>
<td>-4.379 ***</td>
<td>-4.211 **</td>
</tr>
<tr>
<td></td>
<td>(0.900)</td>
<td>(1.210)</td>
<td>(1.220)</td>
<td>(1.110)</td>
<td>(1.250)</td>
<td>(1.350)</td>
<td>(2.680)</td>
<td>(2.650)</td>
<td>(2.570)</td>
</tr>
<tr>
<td>Log(Book Value of Assets)</td>
<td>-0.007</td>
<td>-0.016</td>
<td>-0.012</td>
<td>-0.006</td>
<td>-0.014</td>
<td>-0.010</td>
<td>-0.283 ***</td>
<td>-0.287 ***</td>
<td>-0.285 ***</td>
</tr>
<tr>
<td></td>
<td>(0.550)</td>
<td>(1.270)</td>
<td>(0.880)</td>
<td>(0.460)</td>
<td>(1.150)</td>
<td>(0.800)</td>
<td>(2.870)</td>
<td>(2.820)</td>
<td>(2.830)</td>
</tr>
<tr>
<td>Advertisement Exp. to Total Exp. Ratio</td>
<td>0.147</td>
<td>1.100</td>
<td>0.356</td>
<td>0.392</td>
<td>1.309</td>
<td>0.599</td>
<td>5.602 *</td>
<td>7.323 **</td>
<td>5.981 **</td>
</tr>
<tr>
<td></td>
<td>(0.080)</td>
<td>(0.640)</td>
<td>(0.200)</td>
<td>(0.220)</td>
<td>(0.780)</td>
<td>(0.340)</td>
<td>(1.910)</td>
<td>(2.540)</td>
<td>(2.050)</td>
</tr>
</tbody>
</table>

\[ R^2 \]

| 4.70% | 4.16% | 4.70% | 8.17% | 9.18% | 9.68% | 48.42% | 47.18% | 48.32% |

Note: \( t \)-statistics are reported in parantheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent \( p \)-values, respectively.

361 observations
Table 9

Regressions Results Liability Lines of Insurance for Publicly Traded Insurers: 1997 - 2002

Table displays results of the following cross-sectional time-series regression:

\[ \text{Liability EPR}_{it} = \alpha + \theta + \beta_1 s_{it}^L + \beta_2 s_{it}^C + \gamma X + \nu_i + \eta_t + \epsilon_{it} \]

where Liability EPR\(_{it}\) equals insurer \(i\)'s premiums written net of underwriting expenses in property lines of insurance in year \(t\) divided by the present value of losses incurred net policyholder dividends paid in year \(t\). The insolvency put value relative to total liabilities is used to proxy for the financial strength of the insurer \(i\) in year \(t\). \(s_{it}^L\) is insurer \(i\)'s marginal capital requirement for the liability line of insurance, \(s_{it}^C\), relative to the insurer's overall capital-liability ratio in year \(t\). \(X\) is a vector of control variables. The regression is estimated using ordinary least squares with and without controlling for year and company fixed effects.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Year Fixed Effects</th>
<th>Company Fixed Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>No</td>
<td>1.362 ***</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>(10.000)</td>
</tr>
<tr>
<td>Liability Line Capital-Liability Ratio</td>
<td>No</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>(1.280)</td>
</tr>
<tr>
<td>Relative Liability Line Capital-Liability Ratio</td>
<td>No</td>
<td>0.143 **</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>(2.040)</td>
</tr>
<tr>
<td>Overall Firm Capital-Liability Ratio</td>
<td>No</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>(0.840)</td>
</tr>
<tr>
<td>Insolvency Put per Liabilities</td>
<td>No</td>
<td>0.224</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>(0.580)</td>
</tr>
<tr>
<td>Liability Line Loss Growth Rate</td>
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<td>-1.675</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>(1.470)</td>
</tr>
<tr>
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<td>No</td>
<td>-0.015 *</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>(1.730)</td>
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<td>Advertisement Exp. to Total Exp. Ratio</td>
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<td>2.177</td>
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<tr>
<td></td>
<td>No</td>
<td>(1.640)</td>
</tr>
<tr>
<td>R²</td>
<td>4.63%</td>
<td>5.28%</td>
</tr>
</tbody>
</table>

Note: t-statistics are reported in parentheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent p-values, respectively. 372 observations
Figure 1

Chart displays the average economic premium ratio across all insurers by each A.M. Best financial strength rating category. The economic premium ratio equals the premiums written net of underwriting expenses divided by the present value of losses incurred net policyholder dividend paid for property lines and for liability lines of insurance.
Figure 2
Average Economic Premium Ratio vs.
Overall Firm Capitalization: 1997-2002

Chart displays the average economic premium ratio for each line of insurance as a function of firm-wide capital-liability ratio by decile. The economic premium ratio for each line of insurance equals the premiums written net of underwriting expenses divided by the present value of losses incurred net policyholder dividends paid. Log-linear trendlines are shown by the dashed lines.
Chart displays the average economic premium ratio for each line of insurance as a function of the line specific marginal capital requirement relative to the firm-wide capital-liability ratio by decile. The economic premium ratio for each line of insurance equals the premiums written net of underwriting expenses divided by the present value of losses incurred net policyholder dividends paid. The line specific marginal capital requirement per $1 of liability was calculated using the approach of Myers and Read (2001). Log-linear trendlines are shown by the dashed lines.