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

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ABSTRACT

Under perfect market conditions, standard capital budgeting theory predicts that the hurdle rates on financially intermediated risk products should reflect only non-diversifiable risk and be constant across firms. However, theoretical research by Froot and Stein (1998), among others, suggests that when firms invest in non-hedgeable assets under conditions where capital is costly, project pricing should reflect the covariability of the project with the firm's existing portfolio, even if this covariability represents non-systematic risk. They argue that their theory is especially applicable to financial institutions pricing intermediated risks. Theoretical research also suggests that the prices of intermediated risks will reflect the capital strain that such risks place on the intermediary and hence reflect implicit allocations of capital to the intermediary's business lines (Myers and Read 2001, Zanjani 2002). We test these theoretical predictions by analyzing the prices of insurance risks for U.S. property-liability insurers over the period 1997-2004. Specifically, we regress insurance price variables on capital allocations by line, measures of insurer insolvency risk, and other risk and control variables. The results provide strong support for theoretical predictions that prices of intermediated risks vary across firms to reflect insolvency risk, marginal capital allocations, and non-systematic covariability.

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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 originated by banks, insurers, and other financial institutions.

Froot and Stein (1998) develop a model of capital budgeting and capital structure 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 frictionlessly hedgeable because they are information-intensive and have unique features. Examples of non-hedgeable assets in banking include bank loans to small businesses and the credit-risk component of a foreign exchange swap. Examples in the insurance industry include most types of property-liability insurance policies, including commercial liability insurance and catastrophe reinsurance, and life insurance policies with embedded options.

The other key features of the Froot-Stein model are that financial institutions face frictional costs of holding capital and increasing costs of raising new funds, where the latter element derives from Froot, et al. (1993). 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 thus are exposed to the risk of potentially having to raise costly external capital. In the Froot-Stein model, costly capital and convex costs of raising new funds 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, unhedgeable assets incorporate the standard market covariability term familiar asset pricing theory as well as a term reflecting the covariability of the unsystematic risk of an unhedgeable asset with the other illiquid 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 unhedgeable assets may vary across institutions, violating the law of one price. Froot (2003) generalizes the Froot-Stein model to incorporate customer aversion to the institution's insolvency risk and negatively asymmetric return distributions. The former generalization has the effect of increasing the price of the non-systematic risk covariability factor, and the latter feature adds a third pricing factor.

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). Like Froot (2003), 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 receive 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. As in Froot and Stein (1998), these models imply that prices reflect the covariability of risks with the firm's existing portfolio, not just covariation with the overall securities markets as in conventional capital budgeting (Zanjani 2002), but the mechanism, in the most general sense, incorporates covariability non-linearly through the allocation of capital by line of business.

The overall prediction of Froot and Stein (1998), Froot (2003), and the capital allocation literature is that prices of illiquid, imperfectly hedgeable intermediated risk products should depend upon firm capital structure, the covariability of the risks with the firm's other projects, their marginal effects on the firm's insolvency risk, and negative asymmetries of return distributions. 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, et al. 1999), and policyholders have only limited protection against insurance insolvencies from state insurance guaranty funds (Grace, et al. 2005). Finally, the various property-liability insurance lines of business vary significantly in underwriting risk and in their covariability with other business lines and with insurer asset portfolios, 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 1997-2004. 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 *overall firm sample.* The second sample, which we refer to as the *traded firm sample*, consists of the subset of firms that have traded equity

[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, Froot 2001). 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, and prices appear to be (often very high) multiples of expected loss (Froot 2001). The development of catastrophe bonds and options has provided a new hedging mechanism for insurers, but the volume of risk capital in the insurance securitization market remains rather limited (Lane Financial 2005). Hence, insurance risk remains largely illiquid and unhedgeable, except at a high price in the reinsurance market.

capital. Although we prefer to measure several of the variables used in our analysis based on market value data, only a minority 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 *economic premium ratio (EPR)* suggested by Winter (1994). The EPR is the ratio of the premium revenues net of expenses and policyholder dividends for a given insurer and line of insurance to the estimated present value of losses for the line and provides a measure of the insurer's return for underwriting a line of insurance. Theory predicts that the EPR will be 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 firm'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. Although the Myers-Read model is not dependent upon specific distributional assumptions for the returns on the firm's assets and liabilities, distributional assumptions are required to implement the methodology empirically. In this paper, we assume that assets and liabilities are jointly lognormally distributed so that capital allocation is based on the Black-Scholes exchange option model (Margrabe 1978).

We believe that 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.[2] Moreover, we do not observe individual firm capital allocations and, in fact, insurers do not publicly disclose their capital

[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, Gron 1994a, 1994b, Cummins and Danzon 1997). The EPR is more meaningful than the traditional unit price of insurance, 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.

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 differences in prices observed in the sample. Because it is possible that the predicted relationships could be somewhat 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 support the theoretical predictions. The price of insurance as measured by the EPR is inversely related to insurer insolvency risk, consistent with prior research (Phillips, et al. 1998). Moreover, prices are directly related to the amount of capital allocated to lines of insurance by the Myers-Read model and thus are also directly related to the covariability of losses across lines of insurance. The results thus support the predictions of Froot and Stein (1998) and the capital allocation literature (Myers and Read 2001, Zanjani 2002). Our tests provide somewhat weaker evidence that prices reflect negative asymmetries of return distributions (Froot 2003). Our research adds to the growing body of empirical evidence supporting the theories of the pricing of intermediated risks (e.g., Froot and O'Connell 1997, Baker and Savasoglu 2002, Naik and Yadav 2003). Baker and Savasoglu (2002) investigate capital constraints in bond trading, while Naik and Yadav (2003) study limited arbitrage in mergers and acquisitions. Froot and O'Connell (1997), the only prior paper to test these theories using insurance data, focuses on the market for catastrophe reinsurance, which is important but represents only a small proportion of total insurer revenues. Thus, our paper is the first to test these theories for an entire market for intermediated risks.

The remainder of the paper is organized as follows: In section 2, we review the relevant literature on the pricing of intermediated risks 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 holding capital is costly and 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. Raising new external capital is costly because of the usual arguments regarding informational asymmetries between firms and capital market and for other reasons (Myers and Majluf 1984, Froot, et al. 1993). Frictional costs of holding capital along with convex costs of raising external capital provide the motivation for intermediaries to engage in risk management.[3] In addition, financial institutions are hypothesized to invest in informationally intensive, illiquid assets which cannot be fully hedged in financial markets.[4]

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 institution's pre-existing portfolio of non-tradeable risks. The price of the latter covariability term depends upon the institution's effective risk aversion, which is a function of the convexity of the cost function for external capital as well as the capital structure of the institution. Specifically, the price is inversely related to the amount of capital held by the firm. 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.

An extension of the Froot and Stein (1998) model is presented in Froot (2003), based on the observation that insurance companies in particular are likely to be especially sensitive to insuring risks that adversely affect solvency. Because insurance customers are only imperfectly protected by government guarantees, they are likely to be more sensitive to firm solvency risk than insured bank

[3] The introduction of convex capital costs as a motivation for risk management is due to Froot, Scharfstein, and Stein (1993).
[4] In the case of property-liability insurers, the illiquid, unhedgeable projects are insurance liabilities created by issuing various types of insurance policies. Insurers generally invest in traded assets such as stocks and bonds.

depositors. Also, contract performance risk is likely to be high relative to wealth for insurance policyholders, such customers also are likely to be "more risk averse than capital providers, discounting future claims more heavily on the basis of even relatively small probabilities of failure (Froot 2003, p. 3)." The relatively high customer risk aversion may be driven by behavioral factors and/or by Merton's (1995) argument that customers of financial institutions face higher costs of diversification of the insured risks than investors in market-traded financial assets. Insurers are also likely to be especially sensitive to the costs of holding risks because their project return distributions tend to be characterized by negative skewness. Froot (2003) generalizes the Froot-Stein model to incorporate policyholder insolvency aversion and negatively skewed return distributions.

The result of Froot's (2003) modeling is the development of a three-factor pricing model for non-tradeable, negatively skewed insurance risks. In addition to the market systematic risk factor, the model includes a factor for the covariability of a given risk with the firm's other non-traded risks (the "firm-wide" risk factor) as well as a factor that prices the asymmetry of the insurer's return distribution. The firm wide risk-factor is analogous to the second factor in the Froot-Stein model except that the price of firm-wide risk is greater, reflecting the assumption that policyholders are averse to insolvency risk, in addition to the friction costs of holding capital and the convex costs of raising new capital, as in Froot and Stein. The predictions of the model are similar to those of Froot-Stein, except that Froot (2003) predicts even stronger departures from the prices predicted by perfect market financial models, reflecting policyholder risk aversion and asymmetrical return distributions.

Neither the Froot-Stein (1998) nor the Froot (2003) model incorporates the explicit allocation of capital by line of business. An important early paper on capital allocation is Merton and Perold (1993), who discuss the rationale for the allocation of capital by financial institutions. As in Froot (2003), 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, risk aversion is still present due to bank sales of products not covered by government insurance programs.

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 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 capital should be allocated so that the marginal contribution of each line of business to the insolvency put value is equal (Myers and Read 2001, pp. 549, 559). This ensures that there is no cross-subsidization across lines of insurance. We adopt the approach of equating the marginal default valued among lines in the empirical part of this paper because this reflects insurance bankruptcy law and thus is likely to be reflected in the market prices of insurance.

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) or Froot (2003).

Although the Myers-Read model clearly has normative implications for insurance management and regulation, in this paper we hypothesize that it has positive implications for insurance markets as well. That is, an implicit underlying hypothesis in the present paper 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 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's model is important because it explicitly incorporates elements from both the Froot-Stein (1998) and Froot (2003) models as well as from Myers-Read (2001) and other capital allocation papers. 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), and

Froot (2003) 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) and Froot (2003), 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.[5] 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 discounted cost of holding 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) and Froot (2003).

There is substantial evidence that capital is costly to insurers. Prior research has established

[5] Frictional costs of capital were first introduced in an insurance pricing model by Myers and Cohn (1987).

the importance of corporate income taxation in insurance pricing and management (e.g., Myers and Cohn 1987, Cummins and Grace 1994, Derrig 1994, Harrington and Niehaus 1997). An extensive literature documents the importance of agency costs in the insurance industry (for a review, see Mayers and Smith 2000). Finally, insurance is one of the most heavily regulated industries in the economy, facing stringent solvency regulation and price regulation in important lines of business.

We formulate three primary hypotheses based on the literature on intermediated risks:

> **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), Froot (2003), and earlier papers such as Phillips, et al. (1998), Pennacchi (1987), 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 based on the third factor in Froot's (2003) pricing model, which provides a risk premium for asymmetry risk (see Froot 2003, p. 26). As Froot points out, this factor does not correspond directly to skewness or any group of moments of the return distribution. Hence, we adopt a proxy for asymmetry risk in our empirical tests. Consistent with Froot (2003), where negative asymmetries primarily drive this pricing factor, we adopt a *downside beta* measure of underwriting risk by line of insurance based on the downside beta of market risk developed by Bawa and Lindenberg (1977) and Ang, et al. (2005). The downside beta, which measures the tendency of a line to have large losses at the same time that the industry as a whole has large losses, is defined in the empirical section of the paper.

> **Hypothesis 3:** The prices of insurance across lines of insurance are directly related to the degree of downside risk of the lines.

This provides another non-securities-market risk factor that potentially affects insurance prices.

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 1997-2004. 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 firm sample.* The second sample, the *traded firm sample*, consists of the subset of firms that have traded equity capital. One reason for choosing two samples is that most U.S. property-liability insurers are not publicly traded.

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 Compustat.

Many property-liability insurers operate as subsidiaries of *insurance groups* under common ownership, while others operate as unaffiliated single insurers. Accordingly, we needed to decide whether to conduct the overall firm sample analysis at the company or the group level. We elected to perform the analysis at the company level, based on the rationale that under U.S. corporation law, the creditors of a failed subsidiary claim against the assets of the group unless there has been fraud or malfeasance such that creditors can "pierce the corporate veil" (Easterbrook and Fischel 1985). Thus, a parent corporation can allow a subsidiary to become insolvent without further consequences to the insurance group, implying that company-level insolvency risk should matter in insurance pricing and providing the rationale for conducting the empirical tests at the company-level in the overall firm sample. Because there is a possibility that the parent will elect to recapitalize a failing subsidiary, we include a control variable in our regressions for firms that are unaffiliated single insurers. Because the market value data used to construct some of the variables for the traded firm sample are at the holding company level rather than the subsidiary level, the traded firm analysis is conducted at the group level rather than the company level. This has the advantage of providing a check on whether the results are robust to conducting the analysis for groups rather than individual companies.

The number of firm-year observations in the overall sample is 8,503, and the number of firm-years in the traded firm sample is 868. 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.

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; Gron 1994a. 1994b; Cummins and Danzon 1997; Phillips, Cummins, 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. 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:

$$\boldsymbol{EPR_{ijt}} = \frac{\boldsymbol{NPW_{ijt} - DIV_{ijt} - E_{ijt}}}{\sum_{s=1}^{S} \boldsymbol{(NLI_{ijts} + LAE_{ijts})/(1 + r_{ts})^{s}}} \tag{1}$$

where EPR_{ijt} = the economic premium-to-liability ratio for line i, company j, year t,

NPW_{ij} = net premiums written for line i, company j, year t,

DIV_{ij} = policyholder dividends incurred for line i, company j, year t,

E_{ij} = underwriting expenses incurred for line i, company j, year t,

NLI_{ijts} = net loss cash flow for line i, company j, year t, at time period s following policy issuance,

LAE_{ijts} = net loss adjustment expense cash flow for line i, company j, year t, at time period s,

r_{fts} = U.S. Treasury yield in year t for bill or bond with maturity of s,

S = the number of periods in the loss cash flow stream.

EPR_{ijt} is calculated separately for each company and year of the sample period. 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. Thus, the EPR measures 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 (Taylor 2000). Data to implement the Taylor method were obtained from industry-wide regulatory annual statement data provided in *Best's Aggregates and Averages* (1997-2004), and payout tail proportions were estimated separately for each year. The calculation of loss present values also requires estimates of the U.S. Treasury yield curves for each year of the sample period. Yield curves are based on spot rates of interest extracted from on-the-run Treasury securities using data obtained from the U.S. Department of the Treasury.[6]

Estimating the Variance-Covariance Matrix of Returns

In order to implement the Myers-Read methodology, we need estimates of each firm's variance-covariance matrix, including both the underwriting portfolio and the asset portfolio. Because annual data were not considered adequate to estimate the variance-covariance matrix, we base the calculations for the underwriting portfolio on quarterly data on losses and premiums by line provided by the NAIC. 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.[7] The loss ratio is a standard measure of underwriting returns in 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 year-specific payout tail estimates employed in calculating the economic premium ratios, but the yield curves vary quarterly in the economic loss ratio calculation. The reason for this is that the data required to estimate the payout tail proportions are only available annually. However, the payout tail proportions are quite stable over time, so the use of annual values does not sacrifice any significant degree of accuracy.

Economic loss ratio time series were estimated for each individual line of insurance using industry-wide data. Industry-wide rather than company loss ratio series were adopted because the individual-firm loss ratios tended to be much noisier. The loss ratios were adjusted for seasonality using the U.S. Census Bureau's X-11 procedure. As a robustness check, we also conducted the analysis using firm-specific loss ratios. The results were somewhat noisier but support the same conclusions. Using industry-wide loss ratios is also consistent with the approach used in calculating

[6] The data were obtained from the following web site: http://www.treas.gov/offices/domestic-finance/debt-management/interest-rate/yield_historical_main_shtml.

[7] Normalizing by premiums is important to control for volume changes over the sample period.

return time series for the asset component of the variance-covariance matrix, which is based on economy-wide asset return series rather than individual insurer accounting returns.[8]

To implement the model for the widest possible sample of firms, we aggregate each insurer's lines of business into two primary categories – property lines and liability lines.[9] 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 physical causes versus tort liability judgments determined by the legal system, respectively. As a robustness check, we also conducted the analysis based on other line groupings, such as personal and commercial lines, and obtained similar results.

Because there are several lines of business included in both the property and liability categories and because insurers differ in their individual line business mix within each category, the variance-covariance matrix was estimated at the individual line of business level using industry-wide economic loss ratios. Each firm's underwriting portfolio variances and covariances were then estimated as weighted averages of the elements of the overall by-line variance-covariance matrix, using estimated loss liabilities by line as weights.[10] Thus, the underwriting portfolio variances and

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[8] Because of the way insurers report investment income for accounting purposes, using individual insurer return series would give less accurate estimates of the stochastic properties of asset returns than using economy-wide asset return data. For example, bond income returns are not broken out by the maturity distribution of the bond portfolio. In addition, insurer pricing decisions are based on expected investment returns in the future and not on the so-called "embedded yield" inherent in accounting returns on assets.

[9] Specifically, the property lines of business include automobile physical damage, special property, fidelity and surety, and a miscellaneous line consisting of accident and health, credit, and financial and mortgage guarantee. Liability lines include automobile liability, other (commercial) liability, medical malpractice, workers' compensation, special liability, commercial multiple peril, and homeowners/farmowners. Classification of lines as property and liability is based on Schedule P of the NAIC regulatory annual statement.

[10] Loss liabilities for a line are the present value of expected loss payments plus the unearned premium reserve.

covariances differ by firm and reflect each firm's line of business mix.

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.[11] 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 and asset returns. The calculation was conducted once, based on the entire industry-wide time series of returns from 1991-2004.[12]

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 industry, is then defined as S = V – L. Define the firm's default value (insolvency put option) as $D(V,L,\tau,r_f,\sigma)$, where $D(\bullet)$ = the insolvency put = PV[Max(0,L-V)], τ = 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

[11] 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.

[12] That is, the variance-covariance matrix was estimated using the entire data series from 1991 through 2004, and this matrix was used for all years of the sample period. This approach was adopted based on the assumptions that insurance underwriting loss distributions are reasonably stationary and has the advantage of reducing the sampling error of the estimated covariance matrix. 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.

parameter, σ_L^2 = the volatility of the firm's losses, σ_V^2 = the volatility of the firm's assets, and σ_{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 σ are defined as:

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

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

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

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,

σ_{V_i} = the standard deviation of the log of asset class i, and

σ_{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., $d_i = \partial D/\partial L_i$. In this paper, we assume that the operation of the competitive insurance market results in the equalization across lines of the marginal default values within each insurer. 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:

$$s_i = s - (\frac{1}{\sigma})(\frac{\partial d}{\partial s})^{-1}(\frac{\partial d}{\partial \sigma})[\sigma_{L_iL} - \sigma_L^2) - (\sigma_{L_iV} - \sigma_{LV})] \quad (5)$$

where s_i = allocated surplus per dollar of liabilities for line i = S_i/L_i,

s = the overall surplus-to-liability ratio of the firm = S/L,

σ = firm's overall volatility parameter,

d = the firm's insolvency put per dollar of total liabilities = D/L,

$\partial d/\partial s$ = the partial derivative of d with respect to s (the option delta),

$\partial d/\partial \sigma$ = the partial derivative of d with respect to the volatility parameter σ (the option vega),

σ_{L_iL} = the covariance between the log of losses in line i and losses of the liability portfolio,

σ_{L_iV} = the covariance between the log of losses in line i and the log of assets.

Thus, because $\partial d/\partial s < 0$ and $\partial d/\partial \sigma > 0$, line i's capital allocation is directly proportional to its covariability with the loss portfolio (σ_{L_iL}) and inversely proportional to its covariability with the asset portfolio (σ_{L_iV}). 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.[13] 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.

[13] 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.

Market-Based Estimates of Firm Risk

In analyzing the sample of publicly traded firms, we also use a market-based estimate of firm insolvency risk – specifically, we extend the Ronn and Verma (1986, 1989) option pricing methodology to derive market measures of the riskiness of the insurer. We extend the Ronn-Verma methodology in two important ways. First, our estimates of an insurer's insolvency put recognize that insurance company liabilities evolve as stochastic processes, whereas Ronn and Verma assume that bank liabilities are non-stochastic.[14] 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, σ_x, by solving the following two simultaneous equations based on the formula for the owners' equity call option:

$$E = V\ N(d_1) - L\, e^{-r\tau}\ N(d_2) \tag{6}$$

$$\sigma_E = \frac{N(d_1)V}{E}\sigma_x \tag{7}$$

where E = the market value of equity,
V = the market value of assets,
L = the present value of liabilities,
x = the asset-to-liability ratio = V/L,
τ = 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),
σ_x = the diffusion parameter of the process x = V/L, a function of the diffusion and covariance parameters of the asset and liability processes,
σ_E = the standard deviation of the firm's equity returns,
$d_1 = [\ln(V/L)+(r_f-r_L+0.5\sigma_x^2)\tau]/(\sigma_x\sqrt{\tau})$,
$d_2 = d_1 - \sigma_x\sqrt{\tau}$, and

[14] See Phillips, Cummins, and Allen (1998) for the derivation of the extended option pricing model.

N(•) = the standard normal distribution function.

The equity return standard deviation (σ_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 σ_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_x, for each company is:[15]

$$r_x = r_f - [x_1 r_{L_1} + x_2 r_{L_2} + \ldots + x_M r_{L_M}] \tag{8}$$

where r_{L_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, et al. (1998), the liability drift term r_{L_i} 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. The time to maturity, τ, was set equal to 1 year, based on the rationale that regulatory audits are performed annually.

Downside Underwriting Risk Betas

[15] See Phillips, Cummins, and Allen, 1998, for the derivation of the discount rate.

In addition to controlling for lines of insurance that contribute relatively more to the overall volatility of the insurer's loss process, we also hypothesize that prices of insurance will be higher in lines of insurance subject to relatively high downside underwriting risk. Downside risk is defined as a tendency for losses in a line of business to be high at the same time that overall industry losses are high. Lines with higher downside risk are likely to place more strain on insurer capital structure and deplete internal capital to a greater extent than lines with relatively low downside risk. Essentially, lines with high downside risk have a tendency to deplete capital in states of the world where capital is relatively valuable and more expensive to obtain from external sources. Underwriting lines with high downside risk is expected to be particularly expensive if insurers find these exposures difficult to diversify across large pools of policyholders or by writing insurance across multiple lines of business. For example when a large hurricane hits the coast, many policyholders are impacted at the same time and the event is likely to create losses across multiple lines of insurance.[16]

Of course, individual insurers could potentially diversify these loss shocks away by accessing reinsurance markets because reinsurers diversify over wider geographical areas and across more lines of business. However, catastrophic losses, by definition, create loss shocks large enough to impact the entire industry and therefore have the potential to reduce the internal funds of many insurers and reinsurers at exactly the same time, making these losses particularly costly to finance. In addition, reinsurance markets are known to have limited capacity to handle the largest insurance risks and hedging through reinsurance is expensive (Froot 2001), precisely because reinsurers too are subject to downside risk which cannot be fully hedged.

The downside underwriting risk variable used in this paper is similar in concept to the lower partial moment measure originally proposed by Bawa and Lindenberg (1977) (for a more recent application, see Ang, et al. 2005). The downside risk β_i^D for a line of insurance is defined as:

[16] Hartwig (2005) shows that Hurricane Katrina created large losses for insurers in business interruption, liability, and marine and energy lines of business as well as commercial and personal property insurance.

$$\beta_i^D = \beta_i^- - \beta_i = \frac{\text{cov}(\text{ELR}_i, \text{ELR}_m \mid \text{ELR}_m > \overline{\text{ELR}_m})}{\text{var}(\text{ELR}_m \mid \text{ELR}_m > \overline{\text{ELR}_m})} - \frac{\text{cov}(\text{ELR}_i, \text{ELR}_m)}{\text{var}(\text{ELR}_m)} \tag{9}$$

where ELR_i = economic loss ratio for line of business i,

ELR_m = economic loss ratio for the industry, and

$\overline{\text{ELR}_m}$ = the mean industry economic loss ratio over the time period of our study.

The second term in equation (9) is the standard definition of the underwriting beta for a line of insurance with respect to industry-wide losses. The first term, β_i^-, captures the covariability of losses in line i and industry-wide losses conditional upon industry losses being larger than expected. Lines of business with larger values for β_i^D thus tend to have large losses at times when industry losses are also relatively large. β_i^D is measured using industry-wide economic loss ratios based on the NAIC quarterly data on premiums and losses over the period 1991-2004. After obtaining industry-wide estimates of β_i^D by line, we estimate a weighed average downside beta for each firm in the sample, using as weights the insurer's expected loss liabilities in each line of insurance.

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:

$$\boldsymbol{EPR_{ijt}} = \beta_0 + \beta_1 \boldsymbol{D_{jt}} + \beta_2 \boldsymbol{s_{jt}} + \beta_3 \frac{\boldsymbol{s_{ijt}}}{\boldsymbol{s_{jt}}} + \beta_4 \boldsymbol{I_\ell} + \beta_5 \beta_{ijt}^D + \beta_6 \boldsymbol{r_{Lijt}} + \gamma' \boldsymbol{X_{jt}} + \upsilon_j + \eta_t + \varepsilon_{ijt} \tag{10}$$

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

D_{jt} = the insolvency put value per dollar of liabilities for insurer j 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,

I_ℓ = indicator variable = 1 for the liability line of business and = 0 for the property line,

β^{D}_{ijt} = the downside underwriting beta for insurer j,

$r_{L_{ijt}}$ = growth rate of liabilities for line i, insurer j, year t,

X_{jt} = vector of control variables for insurer j,

υ_j = firm fixed effect for insurer j,

η_t = year fixed effect for year t, and

ε_{ijt} = random error term for line i, insurer j, in year t.

A pooled model is estimated where the dependent variable vector includes the economic premium ratios for both property and liability lines.[17] An indicator variable is included in the equation to allow the intercept term to differ by line. The regression models are estimated by ordinary least squares with White's heteroskedasticity-corrected covariance matrix of the parameters. Specification tests were conducted to determine whether company and year effects were present and whether random or fixed effects estimation would be more appropriate. The results indicated that fixed effects estimation was indicated,[18] although random effects estimation yielded similar conclusions. In addition to the full fixed effects results, we also present results where company fixed effects are omitted.

To test the Hypothesis 1, that price is inversely related to firm insolvency risk, we use the estimated insolvency put values per dollar of liabilities for each insurer. In the overall sample analysis, the put values are estimated using the NAIC annual statement data; and in the traded firm analysis, the put values are estimated using the Ronn-Verma methodology. We also conduct tests where we replace the insolvency put values with the insurers' A.M. Best's financial ratings, as an alternative measure of firm financial strength. The predicted sign of the put option variable, $\boldsymbol{D_{jt}}$, is

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[17] Conducting the regressions separately for property and liability lines yielded similar results.

[18] The Breusch-Pagan Lagrange multiplier test showed that unit effects are present in our data so that either fixed or random effects estimation should be used (Greene, 2000, p. 573). We then conducted Hausman tests of the null hypothesis that the unit effects are orthogonal with the regressors. The hypothesis is clearly rejected, implying that random effects estimation would be inconsistent. Accordingly, the principal results reported are based on two-way fixed effects, with dummy variables for firms and years included in the models. Ordinary least squares estimation produces consistent estimators when used with two-way fixed effects in a panel data model (Greene 2000, p. 576).

negative. In some specifications, we also incorporate the firm's overall surplus to liability ratio, s_{jt}, in the regressions. Because it provides an additional measure of the firm financial strength and because holding capital is costly, 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, s_{ijt}. This variable is entered in the 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_{jt}. 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. To provide information on the hypothesis that the marginal costs of allocated capital are equal across lines of insurance within each insurer, versions of the regression are also estimated where s_{ijt} is interacted, respectively, with an indicator variable equal to 1 for the liability line and with one minus this indicator variable. Using the interactions allows the coefficients of the surplus-to-liability ratios for the property and liability lines to differ. If the marginal costs of capital allocations are equal across lines, these coefficients should not be statistically different.

To test Hypothesis 3, that lines with more downside risk have higher prices, we utilize β_{ijt}^{D}, the firm's downside underwriting beta by line, as a regressor. The expected sign of this variable is positive. In the regressions based on the overall firm sample, this variable is entered directly in the equation and also interacted with indicator variables for publicly traded insurers and mutual insurers, respectively. Because publicly traded insurers have access to capital markets, their prices may be less sensitive to downside risk than non-traded insurers; and because mutuals have more limited access to capital than stock insurers, their pricing may be more sensitive to downside risk.

Several control variables also are included in the regressions. The growth rate in liabilities in line i, $r_{L_{ijt}}$, 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 $r_{L_{ijt}}$ 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 heavy losses. 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 firm 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 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 charge lower prices. Another ownership form variable included in the overall firm sample regressions is a dummy variable set equal to1 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 stock insurers, 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), requiring lower risk loadings, suggesting a negative sign for the mutual dummy variable.

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 (primarily personal auto and workers' compensation) is included in the regressions to proxy for the effects of price regulation. If regulation generally leads to price suppression, the coefficient of this variable is expected to be negative (Harrington 2002).

In the publicly traded insurer analysis, Tobin's Q is included in the regressions as an additional control variable. We define a proxy for Tobin's Q ratio equal to the book value of liabilities plus the market value of equity divided by the book value of assets, based on Compustat data. Q is generally viewed as a proxy for a firm's growth opportunities. Firms with more growth opportunities are likely to be more risk averse because their future prospects are likely to be damaged more significantly by potential shocks to internal capital than firms with lower growth opportunities. Thus, we hypothesize that Q will be positively related to the price of insurance.

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 approximate mid-point of our sample period, is shown in Table 1. The table is based on the overall firm sample, with the data obtained from the NAIC regulatory annual statement database. Consequently, stock investments are reported at market values, but other assets are stated at statutory book values.[19] 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 49.2% of their assets in bonds, 25.6% in stocks, and

[19] Bonds are valued at amortized cost, mortgages are stated at unpaid principal balances, and real estate is at amortized cost less depreciation.

6.9% in cash and short-term invested assets. Non-invested assets, primarily receivables from agents and reinsurers, represent 17.3% of total assets. On the liability side, 66.3% of liabilities represent reserves for unpaid losses in liability lines, 12.0% represent reserves for property lines, and 21.7% represent other liabilities such as reserves for unearned premiums.[20] Liability lines account for the majority of liabilities because these lines tend to have much longer payout periods than the property lines. The industry's economic equity is $478.56 billion which is larger than the statutory book value of equity of $400.25 billion due to the discounting of loss reserves in Table 1.

The estimated industry-wide variance-covariance matrix based on the NAIC quarterly loss ratios and asset return data is shown in Table 2. Among the insurance lines, the highest volatilities are in homeowners and special property, because of their exposure to catastrophic property risks from hurricanes and earthquakes (special property includes earthquake insurance). Fidelity and surety also has high volatility, but these lines combined account for less than 1.5% of industry premium volume. The loss ratios for several lines of business tend to have high bivariate correlations, e.g., commercial multiple peril and workers' compensation (92%) and auto liability and medical malpractice (89%). Omitting the category of "other liabilities," which consists of liability items not related to insurance underwriting, the average covariance among the insurance line loss ratios is 41.1%, and there is only one negative covariance – between homeowners and automobile physical damage. Hence, covariability among lines of insurance is an important factor for insurers to consider in managing risk and pricing insurance.

Stock returns are negatively correlated with the loss ratios for all lines of insurance, suggesting that investing in stocks does not provide a natural hedge for insurers against underwriting risk. Corporate bond yields are negatively correlated with nine of twelve asset categories, and short-term investment returns are negatively correlated with eight categories, indicating that these assets

[20] The classification of lines of business into the liability and property categories is based on Schedule P, Part 2 of the NAIC regulatory annual statement. Some lines such as homeowners and commercial multi-peril include both liability and property coverages. It was not possible to separate the liability and property components of these coverages because insurers do not report the two components separately in many of the annual statement schedules or in the NAIC quarterly database used to estimate the variance-covariance matrix.

also generally do not provide effective hedges for insurers. Government bond yields are positively correlated with several important lines of insurance, indicating that this type of investment does provide a natural hedge for underwriting risk.

Table 3 shows the industry-wide Myers-Read capital allocations for the year 2000. The column headed "capital-to-liability ratio" displays the capital allocation per dollar of liabilities for each line of business. The column headed "relative capital-to-liability ratio" divides the capital-to-liability ratios by the overall industry capital-to-liability ratio for 2000, 0.858. The highest capital-to-liability ratio is for the special property line, which includes earthquake insurance and other lines with high exposure to catastrophe risk. Capital allocations are also relatively high for risky liability lines such as medical malpractice and other (commercial) liability. The lowest capital allocations are for automobile physical damage, automobile liability, and a composite line consisting of accident and health and several other miscellaneous lines. The industry-wide capital allocations shown in Table 3 indicate that a large share of total capital is allocated to other (commercial) liability, because this line is highly volatile and has one of the longest payout tails. The second largest allocation is to automobile liability, which is relatively low risk but is the highest volume line in terms of revenues.

Summary statistics for the variables included in the regression analysis are shown in Table 4 for the overall firm 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 for both samples, 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 because special property, which has the highest surplus-to-liability ratio, is not a high volume line, unlike auto physical damage, which is a high volume line with a low surplus-to-liability ratio. Not surprisingly, the publicly traded insurers (Table 5) are significantly larger in terms of both assets and equity capital than insurers in the overall firm sample (Table 4). Recall that the publicly traded firms consist primarily of insurance groups, whereas the overall firm sample is based on individual companies.

As a first look at the relationship between insurer insolvency risk and the price of insurance, the 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. The plotted points represent simple averages of the economic premium ratios for insurers in each A.M. Best rating category. It is clear from the figure that firms with relatively high ratings command higher prices. The highest prices are for insurers with ratings of A++ through B+ and the lowest are for firms with ratings below B-.

Further evidence on the relationship between firm solvency risk and insurance prices is provided in Figure 2, which plots the economic premium ratio as a function of insurer capital-to-liability ratios (s_{jt}). To obtain the plotted points, insurers are first ranked in ascending order by their capital-to-liability ratios over the sample period. The plotted points are then the simple averages of prices and capitalization ratios for the firms in each decile. The figure shows a generally monotonic relationship between price and overall firm capitalization, consistent with Hypothesis 1.

A first look at Hypothesis 2, i.e., that prices are directly related to capital allocations by line, is provided in Figure 3. This figure plots economic premium ratios against relative by-line capital allocations (s_{ijt} / s_{jt}). As in Figure 2, insurers are then ranked in ascending order by relative capital ratio and placed into deciles. The plotted points are simple averages of economic premium ratios and relative capital ratios by decile. The results support Hypothesis 2, showing a generally positive relationship between price and relative capitalization.

Regression Results

The regression results for the overall firm 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 fixed effects included and excluded.[21] We focus most of the discussion on the regressions that include both company and year fixed effects (the last four columns

[21] Specifications omitting both the company and year fixed effects are very similar to those that include year effects but not company effects and hence are not shown.

in the table), which we consider to be the most appropriate.

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+.[22] Consistent with Hypothesis 1, the coefficients of the Best's rating variables are negative and statistically significant in all specifications of the model, implying that economic premium ratios are higher for insurers with better financial ratings. Moreover, 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 capital allocations by line. Models 1 and 5 include the line surplus-to-liability ratio ($\boldsymbol{s_{ijt}}$), and models 2-4 and 6-8 include the relative surplus-to-liability ratios ($\boldsymbol{s_{ijt} / s_{jt}}$). Both the line ratios and the relative ratios are statistically significant and positive, consistent with the hypothesis that prices are higher for lines of insurance that consume more capital. If the capital allocations accurately reflect the capital stress placed on the firm by writing different lines of business, we do not expect the coefficients of the surplus-to-liability or relative surplus-to-liability ratios to differ by line. In specifications of the model where the capital allocation ratios were interacted with indicator variables for the property and liability lines to allow the slope coefficients to differ by line, F-tests failed to reject the hypothesis that the property and liability coefficients were equal. Accordingly, we

[22] Models which included the firm's estimated insolvency put value as a ratio to liabilities support similar conclusions. We show the models based on Best's ratings here to emphasize the monotonic relationship between price and financial ratings.

report the pooled results in the regression tables.

The regressions shown in Table 6 also provide support for Hypothesis 3, that prices are directly related to the degree of downside risk. In model 8, the downside risk variable is positive and statistically significant, supporting the hypothesis. Model 8 also includes this variable interacted with an indicator variable for publicly traded insurers and with an indicator variable for mutuals. The interaction of the downside risk variable with the publicly traded insurer indicator is negative, statistically significant, and nearly equal in absolute value to the coefficient of the non-interacted downside risk variable. This implies that downside risk is not an important determinant of price for publicly traded insurers, most likely because they have better access to capital than non-traded firms. This result would also be consistent with lower informational asymmetries between traded insurers and capital providers, consistent with traded firms releasing more information than non-traded firms and being followed more intensively by financial analysts and ratings firms. The coefficient of the downside risk variable interacted with the mutual indicator is positive and statistically significant, implying that mutuals are more sensitive to downside risk than stock insurers. Thus, Hypotheses 3 is supported for non-traded stock insurers and mutuals but not for publicly traded firms.

The coefficients of the control variables in the regressions shown in Table 6 are mostly consistent with expectations, although few of them are statistically significant in the models that include company fixed effects. The insurance line loss growth rate is negative and significant in all models, 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 and significant in the models excluding company fixed effects, as expected if larger firms are more diversified and hence have lower risk aversion, other things equal. However, this variable is not statistically significant when company fixed effects are included. 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. However, this variable is not significant in the models with company fixed effects. Similarly, the percentage of premiums in regulated lines of insurance is negative as expected but not significant in the models including company fixed effects.

The indicator variable for membership in a publicly traded insurance group is not statistically significant, indicating no significant intercept difference in the price between traded and non-traded firms. The mutual dummy variable is negative and significant except in the full fixed effects models, where it is positive and insignificant. Hence, there is weak evidence that mutuals have lower prices, perhaps because they tend to focus on less complex and less risky lines of business. Finally, the indicator variable for liability insurance is negative and statistically significant, implying that liability lines have lower prices in general than property lines. This is consistent with property lines having more exposure to catastrophe risk.

The economic premium ratio regressions for the publicly traded firms, shown in Table 7, provide additional support for Hypothesis 1. The market value insolvency put variable is statistically significant and negative in five of six models, including the three full fixed effects models, implying that price is inversely related to insolvency risk. Further support for Hypothesis 1 is provided by the specifications including the firm's overall capital-to-liability ratio (models 3 and 6). This variable is positive and significant, implying that better capitalized firms command higher prices. The Table 7 regressions also provide support for Hypothesis 2. Both the line capital-to-liability ratio (s_{ijt}) and the relative capital-to-liability ratio (s_{ijt} / s_{jt}) variables are positive and statistically significant, implying that prices are higher for lines with higher capital allocations. The Table 7 results do not support Hypothesis 3 – the coefficient of the downside risk variable is negative, contrary to expectations, and not statistically significant in the models including company fixed effects. Thus, downside risk does not appear to play an important pricing role for publicly traded firms.

The coefficients of the control variables in Table 7 are mostly consistent with expectations. The line loss growth rate is negative and significant in all but one regression, providing further evidence that higher growth tends to increase the firm's insolvency put value. The percentage of premiums in regulated lines is also negative and significant in most models, consistent with regulatory rate suppression, but is not significant in the models including company fixed effects. The log of the book value of assets is negative and statistically significant in the full fixed effects models, providing some evidence that larger firms are less risk averse. The proxy for Tobin's Q is positive as expected if firms with more growth opportunities have higher risk aversion, but this variable is not significant in the full fixed effects models. Finally, the indicator variable for liability insurance is negative and significant, providing further evidence that liability lines have lower prices in general than property lines. Overall, the results for the hypothesis tests and control variables are quite consistent for the overall and traded firm samples, indicating that the results are robust to conducting the tests at the company and group levels.

5. Conclusions

Under perfect market conditions, standard capital budgeting theory predicts that the hurdle rates on financially intermediated risk products should reflect only non-diversifiable risk and be constant across firms. However, a growing body of theoretical research suggests that prices for illiquid, imperfectly hedgeable intermediated risks will not be independent of the characteristics of the intermediary but rather will reflect firm capital structure and risk aversion (Froot and Stein 1998, Froot 2003). In particular, prices of imperfectly-hedgeable 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 (Myers and Read 2001, Zanjani 2002). Recent research also suggests that prices will be higher for projects that expose the firm to negative return skewness (Froot 2003). Earlier research predicts, prices of intermediated risks also are predicted to be inversely related to the intermediary's insolvency risk (Cummins 1988, Phillips, et al. 1998).

This paper provides empirical tests of three hypotheses based on the theoretical literature. Hypothesis 1 is that insurance prices are inversely related to insolvency risk. Hypothesis 2 is that insurance prices are directly related to the amount of capital allocated to a project or line of business, reflecting the impact on the firm's insolvency put value of covariability among underwriting and investment returns. Hypothesis 3 is that prices will be higher for projects with more downside risk, defined as relatively high covariability with the firm's overall losses when losses are larger than expected. We test the hypotheses using two samples of U.S. property-liability insurers over the sample period 1997-2004 – a sample consisting of all insurers with usable data reporting to the National Association of Insurance Commissioners and a sample 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, net of expenses and policyholder dividends, divided by the present value of incurred losses for the line. To test the hypothesis that prices are inversely related to insolvency risk (Hypothesis 1), 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 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 regressions to test Hypothesis 2. The results provide strong support for the hypothesis that prices are directly related to capital allocations. Because capital allocations are a function of the covariability among lines of business and among business lines and the firm's asset portfolio, the results are also consistent with the predictions of Froot and Stein (1998), Zanjani (2002), and Froot (2003) that price will be positively related the covariability between a project and the firm's existing portfolio.

To test Hypothesis 3, that price is directly related to downside risk, we include a covariability measure of the downside risk of an insurer's business lines in the regressions. The results indicate that prices are sensitive to downside risk for non-traded stock insurers and mutuals but not for publicly traded stock insurers. This would be consistent with publicly traded firms having better access to capital and lower informational asymmetries between capital providers and publicly traded insurers in comparison with mutuals and non-traded stock firms.

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-hedgeability 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 liquid 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
"Economic Value" Balance Sheet for the U.S. Property-Liability Industry: 2000

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 loss reserves labeled "Automobile Liability" and "Automobile Physical Damage" contains the present value of the reserves for both personal and commercial automobile insurance coverages. The loss reserve "Other Liability" contains the present value of the loss reserves for the lines of business general liability, products liability, international and liability reinsurance. Special Property includes earthquake insurance and commercial property coverages such as fire and inland marine. Special Liability includes several commercial liability lines including aviation, ocean marine, and boiler and machinery. Source: A.M. Best (2001)

Economic Assets	Amount (millions)	Percentage
Invested Assets		
Stocks	$ 265,112	25.58%
Government Bonds	$ 336,650	32.48%
Corporate Bonds	$ 172,779	16.67%
Real Estate	$ 9,494	0.92%
Mortgages	$ 1,617	0.16%
Cash + Other Inv.	$ 71,888	6.93%
Other Assets	$ 179,061	17.27%
Total Economic Assets	$ 1,036,601	

Economic Liabilities and Equity	Amount (millions)	Percentage
Loss Reserves: Liability Lines		
Automobile Liability	110,304	19.77%
Other Liability	107,230	19.22%
Workers' Compensation	64,247	11.51%
Commercial Multi-Peril	34,029	6.10%
Homeowners/Farmowners	29,030	5.20%
Medical Malpractice	20,332	3.64%
Special Liability	4,692	0.84%
Loss Reserves: Property Lines		
Automobile Physical Damage	23,554	4.22%
Special Property	19,794	3.55%
Acc., Credit, Health, Fin. Guar.	18,570	3.33%
Fidelity/Surety	5,246	0.94%
Other Liabilities	$ 121,015	21.69%
Total Economic Liabilities	$ 558,043	
Total Economic Equity	$ 478,559	
Economic Liabilities & Equity	$ 1,036,601	

Table 2

Industry-Wide Variance/Covariance Return Summary Statistics:1991-2004

The table displays standard deviation and correlation statistics of the quarterly time series of returns of the industry's major asset classes and of the underwriting returns for the individual lines of insurance. 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 X-11 procedure before we calculated the summary statistics reported below. The time period begins in the first quarter of 1991 and ends in the fourth quarter of 2004.

			Liability Correlation Matrix											
Liability Class		**Annual Volatility**	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Homeowners/Farmowners	(1)	44.24%	100%	24%	23%	65%	7%	25%	1%	47%	-13%	2%	37%	-26%
Automobile Liability	(2)	10.23%		100%	40%	34%	89%	34%	73%	82%	56%	57%	42%	17%
Workers' Compensation	(3)	21.10%			100%	92%	48%	47%	26%	20%	69%	11%	54%	15%
Commercial Multi-Peril	(4)	24.35%				100%	40%	36%	19%	8%	69%	18%	46%	-10%
Medical Malpractice	(5)	28.30%					100%	66%	79%	75%	66%	50%	48%	29%
Special Liability	(6)	33.97%						100%	24%	23%	65%	7%	25%	10%
Other Liability	(7)	29.11%							100%	74%	30%	53%	44%	22%
Special Property	(8)	48.88%								100%	37%	44%	41%	-16%
Automobile Physical Damage	(9)	9.41%									100%	19%	43%	8%
Fidelity/Surety	(10)	42.18%										100%	20%	21%
Acc., Credit, Health, Fin. Guar.	(11)	9.65%											100%	-17%
Other Liabilities	(12)	4.63%												100%

		Asset/Liability Correlation Matrix											
Asset Class	**Annual Volatility**	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Stocks (S&P 500)	12.31%	-14%	-35%	-22%	-43%	-21%	-4%	-14%	-28%	-17%	-9%	-5%	-24%
Government Bonds (Lehman Brothers)	2.89%	8%	28%	28%	15%	4%	-6%	7%	-30%	-1%	-12%	6%	6%
Corporate Bonds (Moody's)	6.98%	-1%	-12%	0%	-40%	-15%	-18%	5%	-32%	-40%	-2%	9%	-2%
Real Estate (NAREIT Total Return)	9.03%	6%	14%	2%	-18%	1%	-13%	25%	-15%	8%	10%	-5%	8%
Mortgages (Merrill Lynch MBS)	2.73%	5%	20%	23%	7%	-1%	-7%	1%	-38%	-2%	-18%	6%	0%
Cash + Other Inv. (30-day Treasury Bill)	0.50%	-14%	-32%	-30%	-2%	-53%	0%	-48%	-12%	31%	-45%	18%	-11%
Other Assets (NAIC author's calculation)	6.82%	-5%	11%	11%	10%	36%	2%	6%	-5%	9%	8%	-25%	69%

Table 3
Industry-Wide Allocation of Capital for the
U.S. Property-Liability Insurance Industry: 2000

The table shows the marginal capital requirements and the allocation of the equity capital across each line 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 85.8% in 2000.

Line	Capital - to - Liability Ratio	Relative Capital-to-Liability Ratio	Allocated Capital (millions)	% of Industry Capital	% of Industry Liabilities
Liability Lines					
Automobile Liability	0.54	0.63	59,461.3	12.43%	19.77%
Other Liability	1.73	2.02	185,767.4	38.82%	19.22%
Workers' Compensation	0.88	1.03	56,511.8	11.81%	11.51%
Commercial Multi-Peril	1.01	1.18	34,343.8	7.18%	6.10%
Homeowners/Farmowners	1.20	1.40	34,927.9	7.30%	5.20%
Medical Malpractice	1.80	2.09	36,505.2	7.63%	3.64%
Special Liability	1.08	1.26	5,073.1	1.06%	0.84%
Property Lines					
Automobile Physical Damage	0.26	0.31	6,231.6	1.30%	4.22%
Special Property	2.87	3.34	56,731.8	11.85%	3.55%
Acc., Credit, Health, Fin. Guar.	0.30	0.35	5,551.5	1.16%	3.33%
Fidelity/Surety	1.54	1.79	8,075.4	1.69%	0.94%
Other Liabilities	-0.09	-0.10	(10,622.0)	-2.22%	21.69%

Table 4
Summary Statistics All Insurers: 1997-2004

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-lialbity 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 in states that either require approval by the insurance commissioner prior to being used in the market or in states where the insurance department develops the rates. 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.

	N	Mean	Std Dev.	Minimum	Maximum
Dependent Variable: Economic Premium Ratio					
Liability	8,259	1.099	0.388	0.200	4.924
Property	7,157	1.240	0.567	0.200	4.997
Explantory Variables					
Liability Line Variables					
Liability Line Loss Growth Rate	8,259	2.26%	1.51%	-6.40%	13.12%
Liability Line Capital-Liability Ratio	8,259	1.402	1.345	0.088	18.378
Relative Liability Line Line Capital-Liability Ratio	8,259	1.381	0.465	0.201	4.960
Liability Portfolio Downside Risk	8,259	(0.092)	0.455	(0.995)	1.045
Property Line Variables					
Property Line Loss Growth Rate	7,157	1.47%	1.83%	-8.57%	13.20%
Property Line Line Capital-Liability Ratio	7,157	1.212	1.600	0.055	21.972
Relative Property Line Line Capital-Liability Ratio	7,157	1.114	0.709	0.200	4.899
Liability Portfolio Downside Risk	7,157	0.621	0.632	(0.751)	2.663
Company Wide Variables					
Total Assets (000's)	8,503	823,185	3,570,038	1,045	86,044,779
Total Liabilities (000's)	8,503	518,853	2,052,527	345	38,260,954
Equity Capital (000's)	8,503	304,332	1,645,768	651	47,783,825
Asset-to Liability Ratio	8,503	1.788	0.599	1.143	5.379
Overall Firm Capital-Liability Ratio	8,503	1.015	0.770	0.202	4.996
% Premiums in Price Regulated Lines	8,503	18.05%	21.28%	0.00%	100.00%
Ind. if Firm is Member of a Publicly Traded Group	8,503	0.268	0.443	0.000	1.000
Ind. if Firm is Member of a Mutual Group	8,503	0.359	0.480	0.000	1.000
Single Firm Indicator	8,503	0.204	0.403	0.000	1.000
Ind. if firm's A.M. Best Rating is A++ or A+	8,503	0.277	0.448	0.000	1.000
Ind. if firm's A.M. Best Rating is A or A-	8,503	0.510	0.500	0.000	1.000
Ind. if firm's A.M. Best Rating is B++ or B+	8,503	0.150	0.357	0.000	1.000
Ind. if firm's A.M. Best Rating is B or B-	8,503	0.050	0.218	0.000	1.000
Ind. if firm's A.M. Best Rating is C++ or C+	8,503	0.009	0.095	0.000	1.000
Ind. if firm's A.M. Best Rating is C or C-	8,503	0.003	0.051	0.000	1.000
Ind. if firm's A.M. Best Rating is D	8,503	0.001	0.031	0.000	1.000
Ind. if firm's A.M. Best Rating is E or F	8,503	0.001	0.024	0.000	1.000

Table 5
Summary Statistics Publicly Traded Insurers: 1997-2004

Table displays summary statistics of variables used in the empirical tests based upon publicy 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-lialbity ratio. The percent of premiums in price regulated lines of insurance equals the proportion of the insurer's total net premiums written 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 in states that either require approval by the insurance commissioner prior to being used in the market or in states where the insurance department develops the rates. The insolvency put per dollar 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, the overall firm capital-liability ratio, or when the line specific relative capital-liability ration is greater than 5 or less than 0.20.

	N	Mean	Std Dev.	Minimum	Maximum
Dependent Variable: Economic Premium Ratio					
Liability	458	1.095	0.274	0.325	2.706
Property	410	1.221	0.419	0.229	3.318
Explantory Variables					
Liability Line Variables					
Liability Line Loss Growth Rate	458	2.48%	1.54%	-2.21%	10.74%
Liability Line Capital-Liability Ratio	458	1.144	0.846	0.209	6.255
Relative Liability Line Capital-Liability Ratio	458	1.322	0.357	0.296	3.266
Liability Portfolio Downside Risk	458	0.705	0.330	0.020	1.663
Property Line Variables					
Property Line Loss Growth Rate	410	1.99%	2.13%	-6.46%	13.03%
Property Line Capital-Liability Ratio	410	1.043	1.070	0.086	9.015
Relative Property Line Capital-Liability Ratio	410	1.143	0.640	0.205	4.231
Property Portfolio Downside Risk	410	1.346	0.377	(0.403)	1.698
Company Wide Variables					
Total Assets (000000's)	466	$ 22,471	$ 72,125	$ 15.32	$ 798,660
Total Liabilities (000000's)	466	$ 18,539	$ 63,359	$ 9.31	$ 717,854
Equity Capital (000000's)	466	$ 3,933	$ 11,137	$ 5.35	$ 86,658
Asset-to Liability Ratio	466	1.492	0.668	1.045	8.920
Overall Firm Capital-Liability Ratio	466	0.863	0.511	0.242	3.242
% Premiums in Price Regulated Lines	466	21.03%	18.37%	-0.23%	96.53%
Tobin's q	466	1.098	0.229	0.370	2.782
Insolvency Put per Liabilities	466	0.005	0.040	0.000	0.537
Ind. if firm's A.M. Best Rating is A++ or A+	466	0.204	0.403	0.000	1.000
Ind. if firm's A.M. Best Rating is A or A-	466	0.328	0.470	0.000	1.000
Ind. if firm's A.M. Best Rating is B++ or B+	466	0.077	0.267	0.000	1.000
Ind. if firm's A.M. Best Rating is B or B-	466	0.017	0.130	0.000	1.000
Ind. if firm's A.M. Best Rating is C++ or C+	466	0.013	0.113	0.000	1.000
Ind. if firm's A.M. Best Rating is C or C-	466	0.000	0.000	0.000	0.000
Ind. if firm's A.M. Best Rating is D	466	0.000	0.000	0.000	0.000
Ind. if firm's A.M. Best Rating is E or F	466	0.000	0.000	0.000	0.000

Table 6
Economic Premium Ratio Regressions Results: All Insurers 1997 - 2004

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

$$EPR_{ijt} = \alpha + q'\mathbf{A.M.Best_{it}} + \beta_4 s_{jt} + \beta_3 \frac{s_{ijt}}{s_{jt}} + \beta_4 Liability_{ijt} + \beta_5 \beta_{ijt}^{D} + g'\mathbf{X} + \nu_j + \eta_t + \varepsilon_{ijt}$$

where EPR_{ijt} equals insurer j's premiums written net of underwriting expenses in line i in year t divided by the present value of losses incurred net policyholder dividends paid for line i 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 j in year t. s_{ijt}/s_{jt} is insurer j's marginal capital requirement for the ith line of insurance, s_{ijt}, relative to the insurer's overall capital-liability ratio in year t, s_{jt}. $Liability_{ijt}$ is an indicator variable equal to one when the line of business is the liability line and zero otherwise. 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. White's adjustment is used to control for heterskadaticity. The model is estimated using all firm-year-line observations. Individual observations were dropped from the regressions if the economic premium ratio, the overall firm capitalization ratio, or if the line specific relative capital ratio was greater than 5 or less than 0.20.

Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Company Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Variable / Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	1.830 ***	1.890 ***	1.735 ***	1.725 ***	1.104 ***	1.251 ***	1.047 ***	1.036 ***
	(33.830)	(35.430)	(30.910)	(30.690)	(3.310)	(3.770)	(3.090)	(3.060)
Line Capital-Liability Ratio	0.029 ***	-	-	-	0.015 ***	-	-	-
	(10.570)				(3.460)			
Relative Line Capital-Liability Ratio	-	0.059 ***	0.055 ***	0.054 ***	-	0.034 ***	0.034 ***	0.030 ***
		(8.600)	(7.920)	(7.900)		(3.910)	(3.930)	(3.450)
Overall Firm Capital-Liability Ratio	-	-	0.047 ***	0.047 ***	-	-	0.032 ***	0.032 ***
			(8.660)	(8.680)			(3.050)	(3.050)
Indicator = 1 for Liability Line of Insurance	-0.122 ***	-0.133 ***	-0.136 ***	-0.138 ***	-0.110 ***	-0.122 ***	-0.123 ***	-0.116 ***
	(12.650)	(13.180)	(13.510)	(13.730)	(10.040)	(10.180)	(10.260)	(9.410)
Indicator if firm's A.M. Best Rating is A or A-	-0.052 ***	-0.057 ***	-0.051 ***	-0.049 ***	-0.040 **	-0.038 **	-0.040 **	-0.040 **
	(5.590)	(6.140)	(5.480)	(5.230)	(2.420)	(2.340)	(2.430)	(2.420)
Indicator if firm's A.M. Best Rating is B++ or B+	-0.091 ***	-0.105 ***	-0.088 ***	-0.086 ***	-0.093 ***	-0.094 ***	-0.092 ***	-0.091 ***
	(6.560)	(7.640)	(6.340)	(6.150)	(3.590)	(3.620)	(3.520)	(3.500)
Indicator if firm's A.M. Best Rating is B or lower	-0.234 ***	-0.253 ***	-0.227 ***	-0.223 ***	-0.277 ***	-0.282 ***	-0.271 ***	-0.271 ***
	(12.700)	(13.830)	(12.260)	(12.060)	(8.300)	(8.470)	(8.100)	(8.100)
Line Loss Growth Rate	-2.038 ***	-2.131 ***	-2.201 ***	-2.174 ***	-2.160 ***	-2.218 ***	-2.208 ***	-2.201 ***
	(7.890)	(8.200)	(8.490)	(8.380)	(7.920)	(8.120)	(8.090)	(8.060)
Log(Book Value of Assets)	-0.020 ***	-0.024 ***	-0.018 ***	-0.018 ***	0.016	0.006	0.017	0.017
	(7.690)	(9.720)	(7.050)	(6.930)	(1.080)	(0.430)	(1.140)	(1.160)
% Premiums in Price Regulated Lines	-0.059 ***	-0.062 ***	-0.051 ***	-0.051 ***	-0.013	-0.020	-0.012	-0.009
	(3.060)	(3.210)	(2.660)	(2.640)	(0.240)	(0.370)	(0.210)	(0.170)
Single Firm Indicator	0.059 ***	0.066 ***	0.059 ***	0.058 ***	0.035	0.035	0.034	0.034
	(5.360)	(6.020)	(5.400)	(5.240)	(1.240)	(1.250)	(1.240)	(1.210)
Ind. if Firm is Member of a Publicly Traded Group	0.007	0.005	0.007	0.012	-0.018	-0.017	-0.020	-0.016
	(0.710)	(0.590)	(0.710)	(1.320)	(0.930)	(0.870)	(1.040)	(0.850)
Ind. if Firm is Member of a Mutual Group	-0.106 ***	-0.099 ***	-0.101 ***	-0.098 ***	0.048	0.048	0.048	0.038
	(12.430)	(11.460)	(11.730)	(10.350)	(1.600)	(1.620)	(1.600)	(1.260)
Portfolio Downside Risk	0.014 *	0.012	0.005	0.021 **	0.035 ***	0.025 **	0.024 **	0.031 **
	(1.780)	(1.460)	(0.560)	(2.060)	(3.120)	(2.110)	(2.010)	(2.300)
Portfolio Downside Risk x Publicly Traded Ind.	-	-	-	-0.052 ***	-	-	-	-0.032 **
				(3.520)				(2.090)
Portfolio Downside Risk x Mutual Ind.	-	-	-	-0.015	-	-	-	0.038 **
				(1.130)				(2.230)
R^2	7.71%	7.49%	7.94%	8.01%	33.51%	33.52%	33.57%	33.62%

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

15,416 observations

Table 7

Economic Premium Ratio Regressions Results for Publicly Traded Insurers: 1997 - 2004

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

$$EPR_{ijt} = \alpha + \beta_1 \frac{InsolvencyPut_{jt}}{TotalLiabilities_{jt}} + \beta_2 Liability_{ijt} + \beta_3 \frac{s_{ijt}}{s_{jt}} + \beta_4 s_{jt} + g'\mathbf{X} + \nu_j + \eta_t + \varepsilon_{ijt}$$

where EPR_{ijt} equals insurer j's premiums written net of underwriting expenses in line i in year t divided by the present value of losses incurred net policyholder dividends paid for line i in year t. We control for the default risk of the insurer using the insolvency put per dollar of liability variable. The insolvency put is calculated using a version Merton's structural credit risk model extended to incorporate the institutional features of the insurance industry as described in Phillips, Cummins and Allen (1998). s_{ijt}/s_{jt} is insurer j's marginal capital requirement for the i^{th} line of insurance, s_{ijt}, relative to the insurer's overall capital-liability ratio in year t, s_{jt}. $Liability_{ijt}$ is an indicator variable equal to one when the line of business is the liability line and zero otherwise. **X** is a vector of control variables. The regression is estimated using ordinary least squares with and without company fixed effects. Year fixed effects are included in all regressions shown and White's adjustment is used to control for heterskadaticity. The model is estimated using all firm-year-line observations for publicly traded insurers only. Individual observations were dropped if the economic premium ratio, the overall firm capitalization ratio, or if the line specific relative capital ratio was greater than 5 or less than 0.20.

Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Company Fixed Effects	No	No	No	Yes	Yes	Yes
Variable / Model	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	1.590 ***	1.575 ***	1.525 ***	2.699 ***	2.682 ***	2.521 ***
	(9.300)	(9.140)	(8.780)	(3.350)	(3.320)	(3.140)
Line Capital-Liability Ratio	0.035 ***	-	-	0.068 ***	-	-
	(2.820)			(3.560)		
Relative Line Capital-Liability Ratio		0.059 **	0.053 **		0.077 ***	0.082 ***
		(2.480)	(2.220)		(2.690)	(2.910)
Overall Firm Capital-Liability Ratio	-	-	0.050 **	-	-	0.193 ***
			(2.120)			(3.840)
Ind. = 1 for Liability Line of Insurance	-0.207 ***	-0.213 ***	-0.216 ***	-0.153 ***	-0.160 ***	-0.165 ***
	(6.450)	(6.510)	(6.590)	(3.960)	(3.940)	(4.100)
Insolvency Put per Liabilities	-0.571 *	-0.605 *	-0.563	-0.998 *	-0.992 *	-0.956 *
	(1.650)	(1.750)	(1.630)	(1.790)	(1.770)	(1.730)
Tobin's q	0.132 **	0.147 ***	0.122 **	0.083	0.080	0.076
	(2.350)	(2.630)	(2.140)	(0.860)	(0.830)	(0.800)
Line Loss Growth Rate	-2.100 ***	-2.128 ***	-2.169 ***	-3.322 ***	-3.240 ***	-3.453 ***
	(2.920)	(2.940)	(3.010)	(4.330)	(4.220)	(4.520)
Log(Book Value of Assets)	-0.007	-0.009	-0.006	-0.060 *	-0.062 *	-0.058 *
	(0.880)	(1.170)	(0.790)	(1.720)	(1.750)	(1.660)
% Premiums in Price Regulated Lines	-0.217 ***	-0.205 ***	-0.202 ***	-0.054	0.001	-0.112
	(3.230)	(3.020)	(2.990)	(0.330)	(0.000)	(0.670)
Portfolio Downside Risk	-0.136 ***	-0.135 ***	-0.141 ***	-0.057	-0.054	-0.062
	(3.970)	(3.910)	(4.080)	(1.210)	(1.110)	(1.300)
R^2	12.09%	11.90%	12.36%	28.67%	28.17%	29.52%

Note: t-statistics are reported in parantheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent p-values, respectively. 868 observations

Figure 1
Average Economic Premium Ratio by A.M. Best Financial Strength Rating: 1997-2004

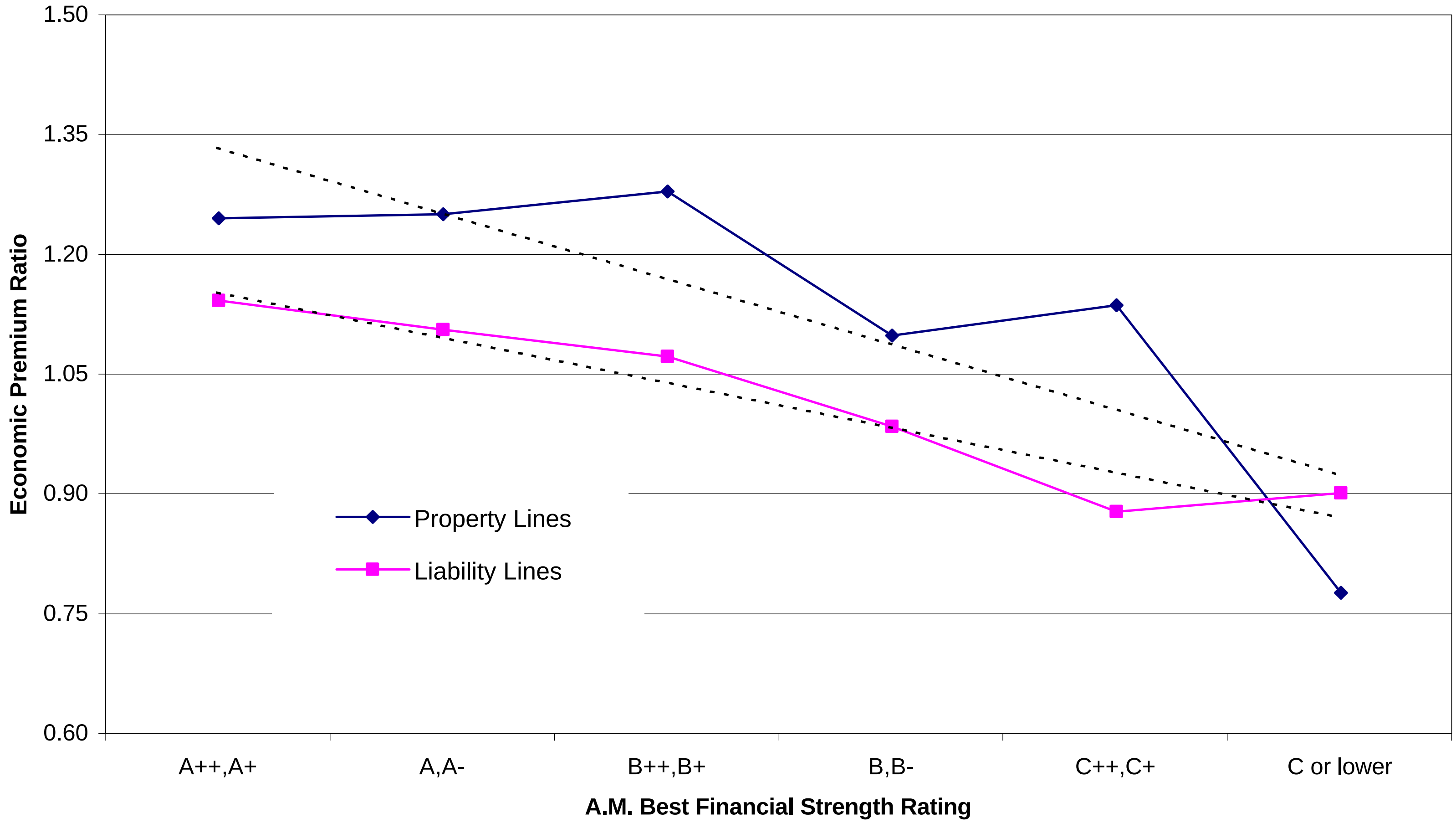

Chart displays the average economic premium ratio across all insurers by each A.M. Best financial strength rating category. The economic premium ratio equals the premiums written net of underwriting expenses divided by the present value of losses incurred net policyholder dividend paid for property lines and for liability lines of insurance. Linear trend lines are shown by the dashed lines.

Figure 2
Average Economic Premium Ratio vs.
Overall Firm Capitalization: 1997-2004

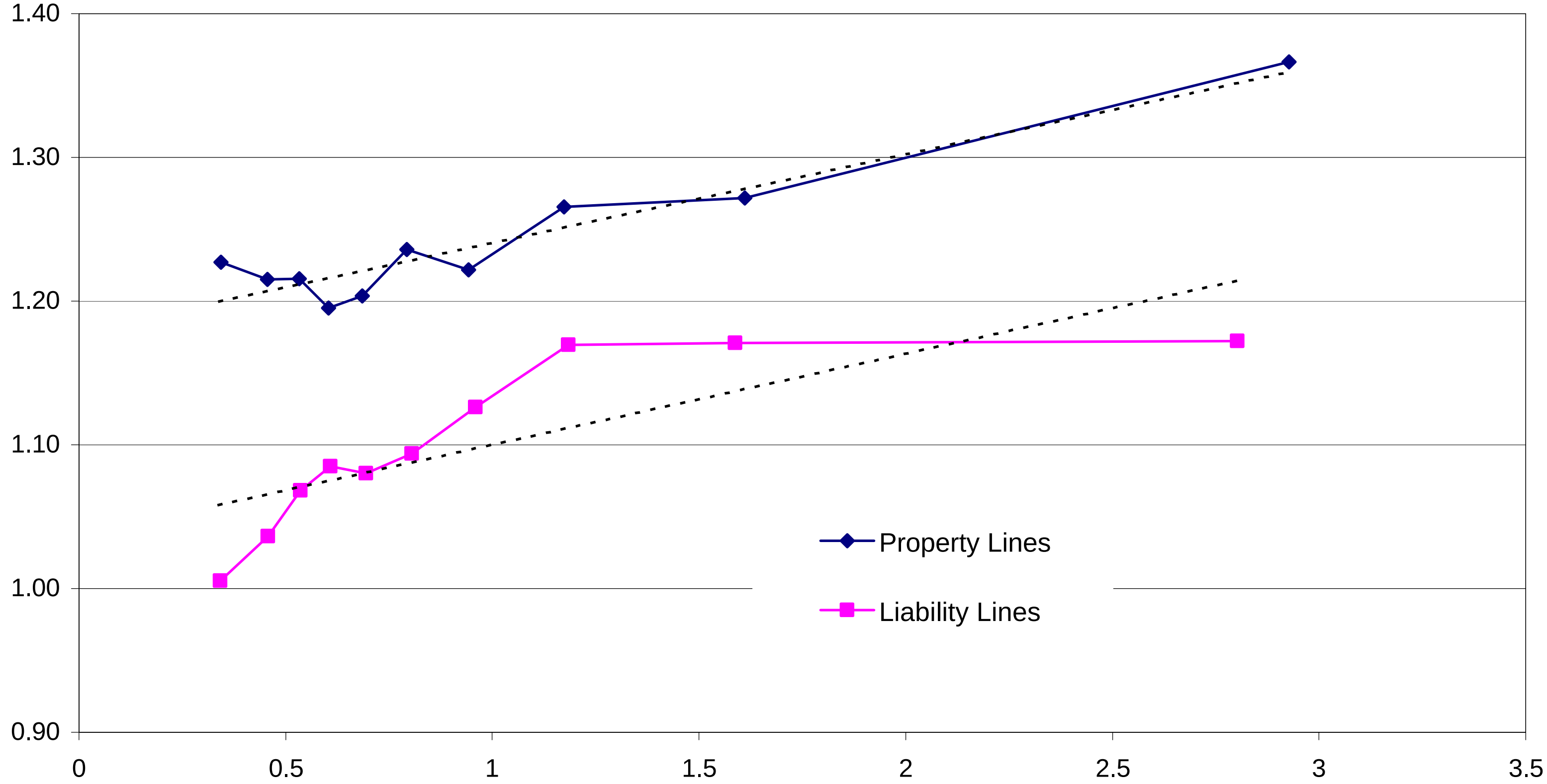

Chart displays the average economic premium ratio for each line of insurance as a function of firm-wide capital-liability ratio by decile. The economic premium ratio for each line of insurance equals the premiums written net of underwriting expenses divided by the present value of losses incurred net policyholder dividends paid. Linear trendlines are shown by the dashed lines.

Figure 3
Average Economic Premium Ratio vs.
Marginal Capital Allocation Requirement: 1997-2004

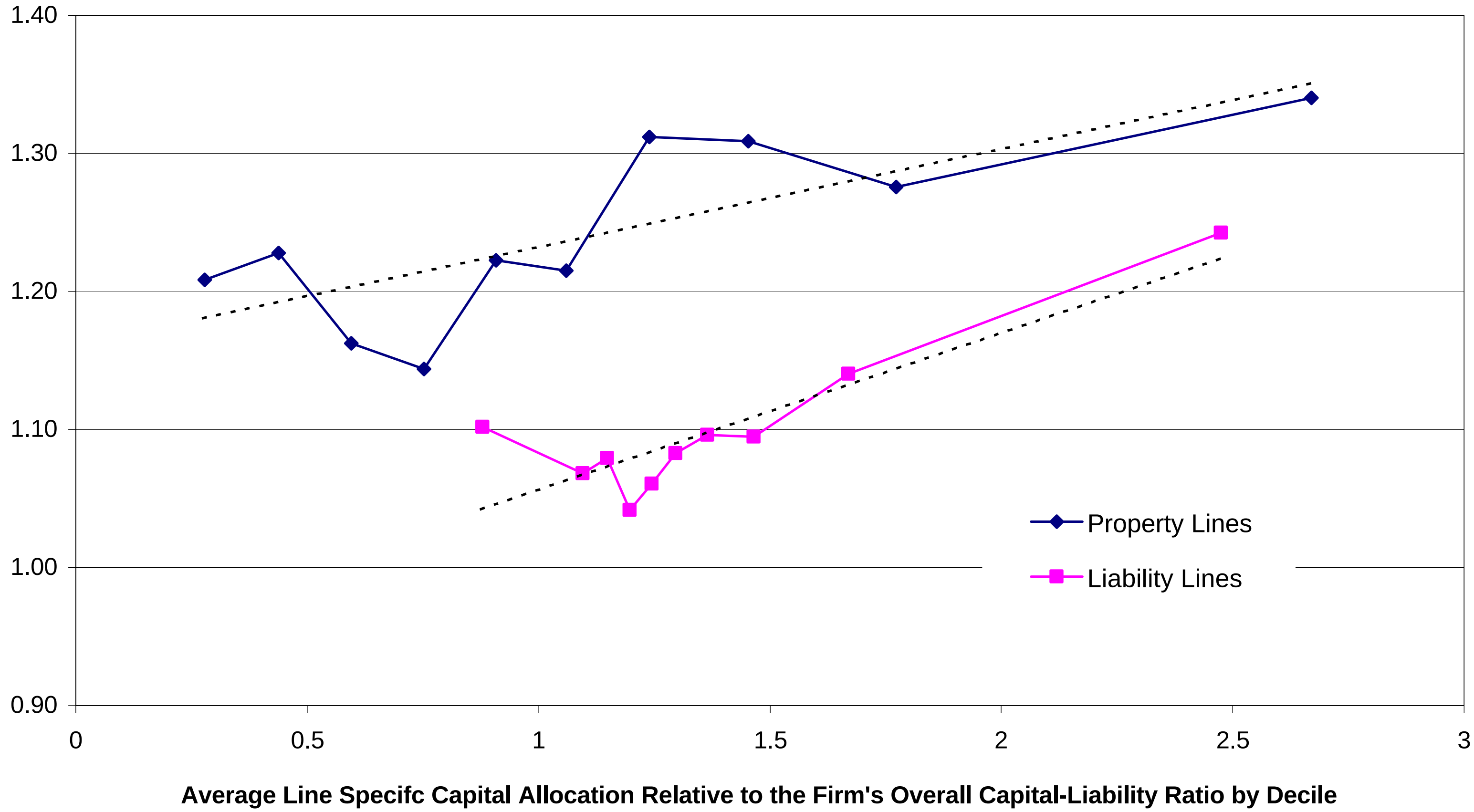

Chart displays the average economic premium ratio for each line of insurance as a function of the line specific marginal capital requirement relative to the firm-wide capital-liability ratio by decile. The economic premium ratio for each line of insurance equals the premiums written net of underwriting 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). Linear trendlines are shown by the dashed lines.