

Capital Allocation and the Price of Insurance: Evidence from the Merger and Acquisition Activity in the U.S. Property-Liability Insurance Industry

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ABSTRACT

This paper examines empirically the impact of mergers and acquisitions on the capital allocation of newly formed insurers as well as on changes in the price of insurance across lines of business of those insurers in the U.S. property-liability insurance industry over the sample period 1995-2004. Our analysis is guided by the theoretical propositions set forth in Froot and Stein (1998) and in the capital allocation literature (Myers and Read, 2001) which predict the prices of illiquid risks depend upon the firm's capital structure, the covariance of an individual line of insurance relative to the riskiness of firm's entire portfolio, and marginal capital allocated to the line of business. This paper also investigates whether changes in the price of insurance across lines reflect the changes in firm insolvency risk and new marginal capital allocation due to M & A activity in the newly formed insurer. We find that M & A leads to reduction in capital requirement (capital-to-liability ratio), lowering the price of insurance in the newly formed insurer. We also provide support for the hypotheses that the changes in the price of insurance across lines are inversely related to the changes in firm insolvency put value and are positively related to the changes in marginal capital allocation.

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1. Introduction

The U.S. insurance industry has witnessed an increasing wave of merger and acquisition (M & A) activity since the early 1990's and a growing literature now exists that provides a number of economic justifications to explain the M & A activity. For example, Cummins, Tennyson and Weiss (1999) suggest technological advances and increasing financial sophistication provide insurers incentives to seek improvements in X-efficiency and economies of scale through M & As. Chamberlain and Tennyson (1998) suggest M & A activity may be a reaction by the industry to fundamental shocks such as industry-wide depletions of capital due to large catastrophes, unanticipated inflation or even adverse asset returns. Mitchell and Mulherin (1996) suggest deregulation in an industry often leads to increased competition and product innovation which then spurs a wave of M&A activity.

Other authors have suggested M & As may improve financial efficiency by creating internal capital markets across diverse business lines which may be valuable to the extent that raising money from external financial markets is costly due to double taxation, agency and information costs (Stein, 1994). BarNiv and Hathorn (1997) find that mergers serve as an alternative form of market exit for insurers that are financially distressed. In contrast, the models of managerial self-interest (Jensen, 1986) predict some M & A activity is driven by managers as they try to acquire assets that necessitate their skills to protect themselves from labor market competition.

Although the economic motivation and valuation effects of M & As in the insurance industry have been discussed, none of these aforementioned studies addresses the impact that M & As activity will have on the capital allocation of newly formed insurers or on the resulting changes in the price of insurance across lines of business of those insurers.¹

We explore that relationship in this paper. Our analysis is guided by the theoretical propositions set forth in Froot and Stein (1998) and in the capital allocation literature (Myers and Read, 2001) which predicts the prices of illiquid and intermediated risks depend upon the firm's capital structure and also on the covariance of an individual line of insurance relative to the riskiness of firm's entire

¹ Capital is defined as the net of total assets over liabilities. Capital is also called surplus in the insurance industry.

portfolio. As Froot and Stein point out in their capital budgeting model, given the capital market frictions that make raising external funds costly, financial firms will behave in a risk-averse fashion and care about risk management. More specifically, Froot and Stein suggest that a business segment's contribution to the overall variability of the cash flows of the bank is an important factor in assessing the risk of a specific segment and in the capital budgeting decision. This implies that firm capital structure, risk management, and capital budgeting are associated together.

Myers and Read (2001) argue the costs of holding equity capital should be allocated to the individual lines of insurance such that the marginal contribution to firm's overall default risk is equal across all lines of insurance. Using this assumption, they develop a capital allocation rule where the capital allocated to the individual lines of business "adds up" to the overall capital of the insurer where prices then reflect these marginal allocations.

In addition to the adding up property, a second important implication of the Myers and Read formulation relates to the portfolio of businesses supported by the capital of the insurer. For example, Myers and Read demonstrate theoretically that diversification by adding more lines of business with low covariability with the insurer's current loss portfolio (or high covariability of loss portfolio with asset portfolio) can decrease the overall capital requirements of the insurer and therefore will lead to more efficient use of capital.² We test this insight in the present paper.

Namely, we investigate whether firms that engage in M & A activity in an attempt to acquire a portfolio of businesses utilize the capital of the firm more efficiently and whether changes in the price of insurance across lines in the newly formed insurer reflect not only the lower overall capital costs but also new capital allocation by lines of business.

The recent empirical study by Cummins, Lin, Phillips (2005) provides evidence that insurance prices are directly related to the marginal capital allocations suggested by the Myers and Read (2001) model and also related to the covariability of losses across lines of insurance predicted by Froot and Stein (1998). We build upon this work by testing whether large changes in the portfolios of an insurer, through M&A activity, are also reflected in prices.

² Capital requirement is measured by capital-to-liability ratio (Myers and Read, 2001).

We use the economic premium ratio as the price of insurance following the insurance literature (e.g., Cummins and Danzon, 1997; Phillips et al., 1998, and Cummins et al., 2005). The economic premium ratio for a line of insurance is defined as premiums written scaled by the estimated present value of losses. We employ Myers-Read methodology to implement marginal capital allocation by line of business. Myers and Read (2001) use the Black-Scholes option pricing model to estimate insurer's insolvency put value and to allocate capital marginally by taking partial derivatives of firm's insolvency put value with respect to the present value of loss liabilities for each line.

The primary data source for the study is from annual regulatory statements filed with the National Association of Insurance Commissioners (NAIC). The samples of M & A are identified through list of Best's Insurance Reports-Property/Casualty. We also utilize the NAIC by-line quarterly data (1991-2002) to estimate underwriting returns which are used to obtain estimates of industry-wide volatilities and correlation matrix between the asset and liability portfolios. The quarterly time series of returns of asset classes are obtained from the standard rate of return series. We analyze merging or acquiring firms (newly formed insurers) that engaged in merger or acquisition over the sample period 1995-2004.

By way of preview, the results of empirical tests provide support for the hypothesis that M & A leads to reduction in capital requirement (capital-to-liability ratio), lowering the price of insurance for the newly formed insurer. We also find that the changes in the price of insurance across lines are inversely related to the changes in firm insolvency risk and are positively related to the changes in marginal capital allocation, consistent with prior literature (e.g., Cummins, Lin, and Phillips, 2005). These findings show the importance of incorporating insolvency risk and marginal capital costs in pricing lines of insurance business and also provide regulation authority with some implications to assess capital adequacy after M & A activity.

The remainder of the paper is organized as follows. Section 2 reviews prior literature on the determinants of the insurance price, and capital allocation. Section 3 specifies the hypotheses to be investigated in the present paper. Methodology and variables used to test hypothesis are presented in section 4. Section 5 describes the data and sample selection criteria. Section 6 provides empirical results and final section concludes.

2. Literature Review

2.1. Determinants of the Insurance Price

How should insurance companies determine premium rates for insurance policies? Traditional actuarial approaches to pricing property-liability insurance contracts take a supply (insurer)-side perspective, relying on retrospective data to estimate the timing and level of future cash flows. Insurance prices are determined by a complex set of supply and demand relationships. Although more modern actuarial models (e.g., Borch, 1974; Buhlmann, 1984) recognize the role of supply and demand in determining insurance price by modeling a market where buyers and sellers of insurance contracts are risk-averse utility maximizers, they have valued insurance apart from any financial market considerations.

The insurance pricing models have developed continually in conformity with changes in tax laws, price regulation, and financial theories. Financial economists use financial theory to address the deficiencies of actuarial pricing models, incorporating the time value of money, investment income and surplus commitments. Financial theory views insurance policies as financial instruments that are traded in markets where prices also take into account the forces of supply and demand (Cummins, 1990b). The financial pricing approaches reflect equilibrium relationships between return and risk and competitive market constraints.

The earliest financial models of insurance are based on the capital asset pricing model (CAPM) (Cooper, 1974; Biger and Kahane, 1978; Fairley, 1979). The CAPM indicates that the invested assets earn the risk free rate of interest plus a risk premium, implying that investors are rewarded for bearing systematic (beta) risk, but not for taking unsystematic risk, i.e., risk that is uncorrelated with the market return. Because the CAPM assumes that investors hold efficient asset portfolios, the market does not reward investors for risk that can be diversified away by holding a properly structured asset portfolio. The CAPM is used to derive the equilibrium rate of underwriting return called the insurance CAPM (Biger and Kahane, 1978; Fairley, 1979; Hill, 1979). Later, the arbitrage pricing model has been applied to insurance pricing (Kraus and Ross, 1982; Urruita, 1987). Myers and Cohn (1987) develop the discounted cash flow model. A significant drawback of these models mentioned above is the lack of recognition of firm default risk. This issue has been addressed by option pricing models. Several authors including Smith (1977), Brennan and Schwartz

(1979), and Doherty and Garven (1986), Cummins (1988), Cummins and Danzon (1997), and Phillips, Cummins, and Allen (1998) have applied option pricing technology to insurance pricing. Both Cummins (1988) and Doherty and Garven (1986) use a more general form of the options relationship where both assets and the exercise price are random. Doherty and Garven (1986) use discrete-time risk-neutral valuation methods, while Cummins (1988) employs the continuous time method underlying the Black-Scholes option pricing formula. Cummins and Danzon (1997) and Phillips, Cummins, and Allen (1998) extend the insurance option model to the multiple-line business. Descriptions and analyses of financial pricing models are presented in Cummins and Phillips (2001).

This section first describes the insurance pricing characteristics and insurance risks that should be taken into account in pricing models. We then outline financial pricing models such as insurance CAPM, discounted cash flow model (DCF), option pricing model. We also discuss the issue of pricing of the intermediated risks under imperfect capital market.

2.1.1. Insurance Pricing Characteristics and Insurance Risks

Financial theory views insurance companies as liability-driven financial intermediaries with equity capital and debt. As corporations issue bonds to raise debt capital, insurers issue debt capital (premiums) in the form of insurance policies. Insurance contracts are roughly analogous to the non-financial corporate bonds. This view suggests that financial theory often used to value traditional corporate debt can be applied to insurance pricing (e.g., Doherty and Garven, 1986; Cummins, 1988).

However, there are some unique characteristics of insurance debt that differ from conventional corporate bonds. For example, when most corporate bonds are issued, the maturity date and coupon payments are known in advance. In contrast, both the payment time and amount on a given contract for property-liability insurance are uncertain and stochastic due to contingent events such as the occurrence of fire and hurricane (Cummins, 1990b). Furthermore, although insurance pricing models often assume that premium is collected at the inception of the policy, it is possible in practice to spread premium payments over the policy period. For example, large commercial insurance lines may pay monthly premiums or may spread premium payments over the first three quarters of the policy year (Feldblum, 1992). In long-tail lines of business like product liability or workers' compensation, losses are not paid

until long after the accident has occurred due to several factors such as loss adjustment procedures and litigated claims.³ Thus, insurance pricing that should incorporate both premium collection and loss payment patterns confronts some different problems that are not present in conventional financial instruments.

The owners of the insurance company provide equity capital to support their insurance writings. When an insurer writes a policy, part of premium is used to pay acquisition, underwriting and administrative expenses. The remaining premiums along with equity capital committed to the firm by shareholders are invested in financial securities such as stocks and bonds to support the unearned premium reserve and the loss reserve. During the time lag between premium payment and loss settlement dates, insurers earn investment income. The shareholders' investment is subject to a layer of taxes. The insurance company has to recover these tax costs when pricing. Investment income is one stimulus for insurance pricing models that account for time value of money. Because insurance cash flows exchanged at different times have different time value of money and investment income is considered in the price-setting process, the risks of economic inflation and interest rate should be taken into account in pricing insurance contracts (Cummins and Phillips, 2001).

Timing differences between premium payments and loss settlements and the resulting investment income were not considered in the earliest accounting pricing methods (Cummins, 1990). The most serious deficiencies of accounting models are that they use retrospective method rather than prospective to estimate cash flows. They typically measure policyholder funds (insurance premium) in proportion to loss reserves and unearned premiums. Reserves are not a perfect proxy for the amount and timing of future cash flow since reserves may be considered sunk costs which are irrelevant in pricing future policies.⁴ In addition, accounting models use embedded yields to obtain the rate of return on policyholder funds. The embedded yield is also unrelated to pricing insurance contracts since policyholder funds (net of expenses) will be invested at current market rates, not at the embedded yield. Most errors of accounting models that prices reflect the insurer's retrospective data can easily be corrected by following the basic principles of capital budgeting set forth in finance texts (e.g., Brealey and Myers, 2000). The recognition of these defects of the earliest

³ Industry-wide loss payment patterns are available from Schedule P of the Annual Statement, but industry-wide premium payment patterns are not available.

⁴ See Cummins and Chang (1983) for detailed discussion.

pricing methods has led to development of more appropriate insurance financial pricing models.

2.1.2. Insurance Capital Asset Pricing Model (CAPM)

The insurance CAPM was developed in Biger and Kahane (1978), Fairley (1979), and Hill (1979) to calculate a fair premium rate. The derivation begins with following formula:⁵

$$\tilde{Y} = \tilde{I} + \tilde{\Pi}_u = \tilde{r}_a A + \tilde{r}_u P \quad (1)$$

Where \tilde{Y}, \tilde{I} = net income and investment income, respectively

$\tilde{\Pi}_u$ = underwriting profit = premium income less expenses and losses

A = invested asset of the firm

P = premiums collected from policyholders

\tilde{r}_a = rate of investment return on assets

\tilde{r}_u = rate of return on underwriting

Tildes indicate stochastic variables. We obtain return on equity by dividing both sides of (1) by equity (G), since invested asset (A) of the firm consists of liability (R) plus equity (G).

$$\tilde{r}_e = \tilde{r}_a \left(\frac{R}{G} + 1 \right) + \tilde{r}_u \frac{P}{G} = \tilde{r}_a (ks + 1) + \tilde{r}_u s \quad (2)$$

Where $s = P/G$ = the premium-to-equity (or premiums-to-surplus) ratio

$k = R/P$ = the liabilities-to-premiums ratio (funds generating factor)

The insurance CAPM can be determined by equating the CAPM rate of return on the insurer's equity with the expected return given by equation (2) and solving for the expected underwriting profit. The resultant formula of the underwriting profit margin is:

$$E(\tilde{r}_u) = -kr_f + \beta_u [E(\tilde{r}_m) - r_f] \quad (3)$$

Where $\beta_u = Cov(\tilde{r}_u, \tilde{r}_m) / Var(\tilde{r}_m)$ = the beta of underwriting profits. The first component of equation (3), $-kr_f$ represents an implicit interest payment to the policyholders for the use of their funds during the period between premium payment

⁵ Notations are taken from Cummins and Phillips (2001).

and loss settlement. The interest payment will reduce required profits on underwriting depending on the size, k , of the policyholder funds and the risk-free interest rate, r_f . The second term is to compensate the insurance company for the systematic risks of underwriting. One of the limitations for this model is that they did not take into account default risk.

2.1.3. Discounted Cash Flow Model

The most prominent discounted cash flow (DCF) models developed by Myers and Cohn (1987) and by the National Council on Compensation Insurance (NCCI) are based on concepts of capital budgeting. In capital budgeting, decision rules such as the net present value (NPV) or internal rate of return (IRR) method are utilized to accept or reject projects (Brealey and Myers, 2000). A fundamental principle of finance is that the value of any asset is equivalent to the present value of its cash flows. Because insurance cash flows on a given contract occur at different times, the DCF models provide an accepted approach to pricing insurance contracts.

Under DCF models,⁶ all of the cash flows that include premiums, expenses, taxes and loss payments are projected, period by period and are then discounted to the beginning of the policy period by the appropriate discount rate. Myers and Cohn (1987) use a risk-adjusted discount rate, whereas NCCI model uses an internal rate of return to obtain a fair and competitive premium.⁷ Both Myers and Cohn and NCCI models are widely used. The former are discussed in this section. Myers and Cohn (1987) determine the fair premium (P) as the present value of (1) loss and expense payments (L), (2) taxes on the investment balance (IBT), and (3) taxes on underwriting profits (UPT):⁸

$$PV(P) = PV(L) + PV(IBT) + PV(UPT) \quad (4)$$

Premium flows are discounted at the risk-free rate since they are assumed to be riskless. However, loss flows are uncertain and risky, and thus are discounted at the risk-adjusted discount rate. An important feature of Myers and Cohn model is the concept of the surplus flow. Surplus is committed when the policy is written and it is

⁶ Cummins (1990) documents that accounting numbers are irrelevant in a DCF analysis except as they directly impact cash flows, implying that loss reserves and loss development factors are not related to DCF models.

⁷ See Cummins (1990) for detailed comparison between Myers and Cohn and NCCI models

⁸ The premium is defined as fair if insurer is indifferent between selling the policy and not selling it in terms of the market value of the insurer's equity.

released when the losses are paid. The insurance contract is a promise that compensates policyholders if contingent events occur. The worth of the promise depends on the financial strength of the insurer. The surplus committed by the shareholders supports its promise. The surplus committed to writing policy and premiums paid in advance (investment balance) are invested and a tax on the investment income should be paid at the end of the time. It is assumed that the funds (surplus plus premium) are invested at the risk-free rate, and therefore the tax on investment income is discounted at that rate. Tax shields that generated from underwriting losses are used to offset taxes on investment income or taxes on insurer's underwriting profits. Assuming that loss and expense payments (L), taxes on the investment balance (IBT), and taxes on underwriting profits (UPT) are paid at the end of the time period, simplified premium formula in a two-period model is:⁹

$$\begin{aligned}
 P &= \frac{L}{(1+r_L)} + \frac{P\tau}{(1+r_f)} - \frac{L\tau}{(1+r_L)} + \frac{(P+E)r_f\tau}{1+r_f} \\
 &= \frac{L}{(1+r_L)} + \frac{\tau S r_f}{(1-\tau)(1+r_f)} \tag{5}
 \end{aligned}$$

Where S = surplus committed by shareholders at the beginning of the time period

r_L = risk-adjusted discounted rate

r_f = risk-free rate

τ = corporate income tax rate

The Myers and Cohn model is consistent with financial theory. However, how to estimate the risk-adjusted discount rate by line of business and the possibility of firm's default are not considered. In addition, the question of the appropriate level of surplus commitment remains unanswered.

2.1.4. Option Pricing Model

The option pricing models have been applied to insurance pricing by several authors (e.g., Doherty and Garven, 1986; Cummins, 1988; Cummins and Danzon, 1992; Cummins, Phillips, and Allen, 1998). These option pricing models not only

⁹ The model generalizes directly to multiple periods with assumption that claims payouts are proportionally separated each period (Myers and Cohn, 1987)

incorporate insurer's default risk, but also estimate key parameters more accurately than the previous pricing models like Myers and Cohn (1987) model.

The basic insurance option pricing models view insurance pricing as analogous to the pricing of risky corporate debt (e.g., Doherty and Garven, 1986; Cummins, 1988). The value of insurer's promise to policyholders can be considered equivalent to the value of the riskless bond minus a put option written on the value of the firm. Although these option models (single period) studied by Doherty and Garven (1986) and Cummins (1988) provide important insights into insurance pricing, they have some limitations. For example, although most property-liability policies have multiple cash flows, basic option models assume a single payoff. These models also assume that insurers produce only one type of insurance, whereas most real-world insurers write multiple types of coverage such as homeowner's insurance, auto insurance, medical malpractice insurance, and workers' compensation (Cummins and Phillips, 2001).

To remedy these defects, Cummins and Danzon (1997) and Phillips, Cummins and Allen (1998) extend the basic insurance option model to the case of multiple lines of business. The model developed by Phillips, Cummins and Allen (PCA) is discussed in this section.¹⁰ PCA assume that financial markets are competitive and perfect, and there are two groups of potential insurance buyers. It is also assumed that premium, equity, and liabilities follow geometric Brownian motion process:

$$\begin{aligned}
 dP_i &= \mu_{P_i} P_i dt + \sigma_{P_i} P_i dz_{P_i} \\
 dG &= \mu_G G dt + \sigma_G G dz_G \\
 dL_i &= \mu_{L_i} L_i dt + \sigma_{L_i} L_i dz_{L_i}
 \end{aligned} \tag{6}$$

Where P_i, G, L_i = premium, equity, market values of liabilities for $i=1, 2$

$\mu_{P_i}, \mu_G, \mu_{L_i}$ = drift parameters for premium, equity and liabilities for $i=1, 2$

$\sigma_{P_i}, \sigma_G, \sigma_{L_i}$ = diffusion parameters for premium, equity and liabilities for $i=1, 2$

dz_{P_i}, dz_G, dz_{L_i} = increments of the Brownian motion processes

for premium, equity and liabilities for $i=1, 2$

The Brownian processes of liabilities and assets are correlated each other as follows:

¹⁰ Notations are taken from PCA (1998)

$dz_{L_1} dz_{L_2} = \rho_{L_1 L_2} dt$, $dz_{L_i} dz_G = \rho_{L_i G} dt$, $dz_{P_i} dz_{L_j} = \rho_{P_i L_j} dt$ for $i=1, 2$ and $j=1, 2$. The premium, surplus and liabilities are presumed to be priced according to the intertemporal capital asset pricing model (ICAPM), implying the following expected rates of return relationship:

$$\begin{aligned}\mu_{P_i} &= r_f + \pi_{P_i}, \text{ for premium } i=1, 2 \\ \mu_G &= r_f + \pi_G \\ \mu_{L_i} &= r_{L_i} + \pi_{L_i}, \text{ for liability class } i=1, 2\end{aligned}\quad (7)$$

Where r_f = risk free rate, r_{L_i} = inflation rate for liability class i , $i=1, 2$ and π_j = the market risk premium for process $j = P_i, L_i$, and G , $i=1, 2$.

If ICAPM is applied to the pricing of assets and liabilities, the risk premium is:

$$\pi_j = \rho_{jm} (\sigma_j / \sigma_m) (\mu_m - r_f) \quad (8)$$

Where μ_m, σ_m = drift and diffusion parameters for the Brownian motion process for the market portfolio and ρ_{jm} = the correlation coefficient between the Brownian motion process for the market portfolio and asset class j , where $j = P_i, L_i$, and G , and $i=1, 2$.

Given these premises of the pricing model and assuming that shareholders of the insurer have limited liability, the insurer has an option at the end of period when the payments of liability are due. The insurer can pay off the liabilities (L) if the premium account (or assets, A) exceeds the losses payable to policyholders and then shareholders will receive the residual value. The value of the shareholders' claim on the insurer at the end of period is $\text{Max} [A-L, 0]$. The shareholders' claim can be viewed as a call option on the insurer's assets (A) with exercise price (L). If the insurer's assets are not sufficient to cover the liabilities, the insurer with limited liability can declare bankruptcy and turn its asset over to the policyholders. The policyholders' claim at the end of period is directly analogous of the claim of the bondholders in a levered firm, i.e., $\text{Min} [L, A] = L - \text{Max} [L-A, 0]$. Thus, the policyholders' claim is equal to the value of liabilities less the value of a put option known as the insolvency put.

Assuming that there is no frictional costs in the insurance markets, PCA derive the market value of line i 's claim on the insurer as follows:

$$P_i = L_i e^{-(r_f - r_{L_i})\tau} - w_{L_i} I(A, L, \tau) \quad (9)$$

Where P_i = the market value of line i's claim on the firm

L_i = the nominal losses owed to line i

r_f, r_{L_i} = the risk-free rate and the liability inflation rate of line i

τ = time to expiration of the option

$w_{L_i} = L_i / L$

$I(A, L, \tau)$ = the insurer's overall insolvency put

Equation (9) means that the market value of the policyholder's claim for line i is equal to the nominal expected value of loss liabilities at the expiration period, discounted at the risk-free rate, minus the line i's share of the insurer's overall insolvency put option. PCA state that insolvency risk in line i's claim depends on the firm's overall insolvency risk, not just on the line-specific levels of risk since insurer's entire equity capital is available to any line of business where the losses are larger than expected. Thus, market value of the line-specific claims on the insurer are not expected to vary after controlling for different liability growth rates by line and insurer's overall default risk. PCA investigate empirically their theoretical model by using data on the publicly traded property-liability insurance companies. They find that the price measure for the short and long-tail lines within a given firm does not vary after adjusting for line-specific liability growth rates. PCA also provide evidence that the price of insurance is inversely related to firm default risk, consistent with the results of Sommer (1996), and Cummins and Danzon (1997).

Cummins and Phillips (2001) document that option pricing models often depend on the assumptions of no-arbitrage and market completeness which are difficult to justify for some insurance products. Additional research is needed to develop more realistic pricing models in imperfect capital markets with frictions.

2.1.5. Capital Allocation and Pricing of the Intermediated Risks under Imperfect Capital Market

Froot and Stein (1998) model the interaction between the capital budgeting and risk management functions of financial intermediaries under imperfect capital market situations where it is costly for financial intermediaries to raise new external funds on short notice and it is also costly to hold sufficient capital as a cushion for

uncertain events. In their model, it is assumed that firms invest in liquid assets that can be frictionlessly hedged in the capital market as well as illiquid assets that can not be easily hedged. The costs associated with raising new external capital are also assumed to be a convex function of the size of the equity capital. The firm has an initial portfolio and chooses its capital structure at time 0. At time 1, the firm can invest in new risky products and makes hedging decisions for both initial portfolio and new risky products. The investment can be financed out of external sources. Uncertain payoffs at time 2 not only affect firm's need to raise costly external funds, but also give an incentive for the firm to care about risk management.

Based on their capital budgeting model, Froot and Stein (1998) demonstrate that the hurdle rate for illiquid, intermediated risks depends on the covariance of business segment with the market portfolio (systematic risk) as well as on the covariance with the firm's pre-existing portfolio of non-tradable risks (unsystematic risk).¹¹ Intuitively, the price of illiquid assets such as insurance policies reflects the covariance of an individual line of business with the riskiness of insurer's entire portfolio and insurer's capital structure, implying that prices across lines of business may vary.

The capital allocation literature (e.g., Merton and Perold; 1993, Myers and Read; 2001, Perold; 2001, and Zanjani, 2002) is also related to the pricing of intermediated risks (The details of capital allocation are discussed in section 2.2 and 2.3). Capital allocation literatures posit that customers of financial intermediaries are strongly risk-averse to firm default risk and thus financial intermediaries have an incentive to reduce insolvency risk by holding more capital, investing in safer assets, obtaining high quality reinsurance, diminishing interest rate risk and diversifying across lines of insurance. Assuming that insolvency risk mostly depends on the amount of capital retained by financial firms, additional capital may benefit financial intermediaries such as banks and insurance companies by increasing the demand for firm's products by consumers who are averse to insolvency risk (Cummins and Danzon, 1997) and by reducing the likelihood that firms lose franchise value (Cagle and Harrington, 1995). However, maintaining financial capital is costly due to financial market imperfections such as corporate taxation and agency costs. Thus,

¹¹ Froot (2003) recently extends their valuation function model incorporating asymmetrically distributed risks in formal corporate pricing and allocation metrics

because of these costly risk management methods, safer insurance companies may require high price for their products (e.g., Cummins, Harrington and Niehaus, 1994).

In sum, the implication from the brief review of risk management and capital allocation literatures is that the price of given line of business reflects firm capital structure, costly surplus requirements and their allocation to individual lines of business, and the covariability among lines of insurance and between firm's overall assets and liability portfolio.

2.2. The Rationale of Capital Allocation

Because most policyholders purchase insurance policies to protect against adverse financial contingencies and they are strongly risk-averse with respect to insurer default on contractually-promised payoffs, insurers need to hold capital in order to secure policyholders' unexpected claims (Merton and Perold, 1993). The principal role of holding capital in the insurance company is to keep the probability of bankruptcy low by increasing ability to pay insurance claims even under adverse circumstances. However, holding capital is costly because of frictional costs that include double taxation, regulatory and agency costs.¹² More precisely, when shareholders provide capital to insurance companies, the investment return is first taxed at the corporate level as insurer's taxable income and then again as part of shareholder's taxable income when distributed as dividends.¹³ Regulatory costs occur due to regulatory restrictions that may require insurers to hold minimum levels of capital or in the form of conservative reserving standards. Shareholders may demand an additional return on their investment due to these frictional costs and thus in order to be profitable, insurers should issue insurance policies with more than their production costs including frictional capital costs (Hancock, et al., 2001; Myers and Read; 2001).

Given that holding capital is costly and insurers should keep a specified level of capital to meet regulation requirements, managing the cost of capital is of particular importance in providing insurance policies, especially catastrophe insurance that needs large amounts of supporting capital. As the amount of capital held increases, the frictional costs of holding capital may consist of large portion of the insurance

¹² Froot, Scharfstein, and Stein (1993) and others illustrate that costly external finance and frictional costs of holding capital are the driving force behind the firm's motivation to manage risk.

¹³ Smith and Stulz (1985) note how nonlinear (or convex) tax schedules give rise to a rationale for hedging.

premium (Zanjani, 2002). Thus, insurers that properly manage them will have a competitive advantage in pricing.

Insurers have an incentive to manage capital costs through risk management. Effective risk management not only promotes stability, but also provides a protection against unexpected losses. This protection is obtained primarily through the maintenance of an appropriate level of economic capital by financial institution. The risk management process involves estimating how much risk each business segment contributes to the total risk of the firm and thus to overall capital requirements. Capital held by the firm is then allocated across lines of business reflecting the varying risk level of individual lines of business. All else equal, more(less) risky lines may require more(less) capital and thus demand higher (lower) prices. Because policyholders are concerned about counterparty default risk on contractual promised payments, they prefer insurer's strong financial strength that guarantees to pay unexpected losses and thus, are willing to pay more for that.

Myers and Read (2001) argue that the essential rationale of the capital allocation is to allocate the frictional costs of holding capital to the individual lines of business depending on the marginal contribution of individual lines of business to firm's overall default value. Specifically, if a new line of business through M & A activity is added to the existing portfolio, additional capital that is needed to obtain an insurer's desired default value will be determined. Once this additional capital amount is known, the cost of surplus due to adding a new line of business can be calculated.¹⁴ The additional capital summed up over insurer's all lines of business yields the total amount of equity capital of the insurer. Thus, capital allocation can be considered a way to represent the allocation of the costs of holding capital.

2.3. Methods of Capital Allocation

It is well documented in the financial pricing of insurance literatures that option pricing model is utilized in analyzing firm default risk and surplus requirements (e.g., Doherty and Garven, 1986; Cummins, 1988, and Phillips et al,1998). The option pricing model is also adopted to calculate marginal capital allocation (Merton and Perold, 1993; Myers and Read, 2001). Both Merton-Perold and Myers-Read provide a capital allocation rule based on a default insurance concept.

¹⁴ Cummins and Phillips (2005) develop the estimation model of cost of capital by lines of business in the property-liability insurance industry using full information industry beta approach.

Merton and Perold (1993) capital allocation is conducted using incremental method. For example, assuming firms with three lines of business, the first step is to calculate the risk capital required by firms that combine two of business lines.¹⁵ The second step is to calculate the risk capital required for the full portfolio of businesses of the firms, i.e., adding the excluded business to the two-business firms. Marginal capital allocation by line of business is then the difference between the risk capital of two-business firms obtained from the first step and the required risk capital for all three businesses. Merton and Perold show that the risk capital of a multi-line business firm is less than the aggregate risk capital of the business on a stand-alone basis when the businesses are not perfectly correlated with one another. Merton-Perold method is appropriate when considering entering new businesses or getting out of existing businesses since their methodology allows for discrete changes in the portfolio of businesses of the insurer. However, the key deficiency of their model is that 100 percent allocation is not feasible across the lines of business.

Unlike Merton-Perold method, Myers-Read method (2001) uniquely allocates 100 percent of total capital of the firm. Relying on the assumption that insurer's future losses and asset values are lognormally or normally distributed,¹⁶ Myers and Read use the Black-Scholes option pricing model to estimate insurer's insolvency put value. Assuming an entity with limited liability, an insurance company does not pay losses if loss liabilities exceed insurer's assets. The insurer defaults and the payoff to policyholder is loss minus max (L-V, 0) where L represents losses and V is assets. Insolvency put value is measured as max (L-V, 0). It can be said that the insurer holds an option to put the default costs to the policyholders. As the insurer has the option to default on their liabilities in the event of insolvency, this insolvency put option can be an asset to the insurer, but lowers the present value of insurance policy and the premium a policyholder is willing to pay for it. As mentioned earlier, maintaining solvency ability to a specified level causes frictional costs for an insurer.

Myers-Read (2001) argue that marginal contribution of individual lines of business to firm's overall default value does vary and surplus (equity capital) should be allocated by lines of business based on these marginal contributions such that the

¹⁵ Merton-Perold(1993) define risk capital as the smallest amount that can be invested to insure the value of the firm's net assets against a loss in value relative to the risk-free investment of those net assets.

¹⁶ Myers and Read emphasize that their result is independent of the distribution assumptions for the insurer's entire losses and assets portfolio(2001, p.573)

marginal contribution to firm's overall default value is equal across all lines of insurance. They find a unique capital allocation method that leads to the "adding up" property; the equity capital allocated to the individual lines of business "add up" to the overall equity capital of the insurer. In their model, although the total capital requirement of the insurer is not explicitly specified, it could be taken to be the amount of capital to keep up the desired safety level of the insurer.

Zanjani (2002) develops multi-line insurance pricing and capital allocation model. He demonstrates that capital costs have a significant impact on the prices of intermediated risks, based on three key assumptions that (1) insurers are exposed to default risk due to uncertain loss events, (2) it is costly for insurers to hold capital, (3) consumers care about the insolvency risk of insurers. Capital market frictions provide an economic rationale for risk management and capital allocation by lines of business depends on the contribution of an individual line of business to the overall firm insolvency risk. Consumer demand for product quality may lead firms to charge high prices for high-risk segments, which is driven by high marginal capital requirements (Merton and Perold; 1993; Myers-Read, 2001). Zanjani proposes that "price differentials across market are explained by differences in marginal capital requirements. Segments with risk that threatens company solvency will have higher marginal capital requirements and higher prices due to implicit capital costs, even if that risk is unrelated to the broader securities markets." which is consistent with the results of Froot-Stein (1998), and Myers-Read (2001).

We employ Myers-Read methodology to calculate marginal capital allocation by line of business in the present paper. This section describes their estimation of volatility and correlation matrix between asset and liability portfolio that are needed to implement capital allocation. We then discuss Myers-Read's formula to estimate insolvency put value and marginal capital allocation.

2.3.1. The Estimation of Volatility and Correlation Matrix between Asset and Liability Portfolio

The critical parameters that need to be estimated to implement Myers-Read capital allocation are the volatility and the correlation matrix for both asset portfolio returns and liability portfolio returns. Other things equal, insurer's insolvency risk is related to the amount of capital that insurer holds. Given the certain amount of capital, the insolvency put value of the insurer depends on the respective volatility of asset

return and loss return series, the correlation between loss return series across lines of business, the correlation between asset portfolios return series, and correlation between asset portfolio return and liability portfolio return series (Myers and Read, 2001).

The respective volatility for asset portfolio returns (σ_V) and liability portfolio returns (σ_L) and covariance of the log losses returns and log asset returns (σ_{LV}) are estimated by the following expressions:¹⁷

$$\sigma_V^2 = \sum_{i=1}^N \sum_{j=1}^N y_i y_j \rho_{V_i V_j} \sigma_{V_i} \sigma_{V_j} \quad (10)$$

$$\sigma_L^2 = \sum_{i=1}^M \sum_{j=1}^M x_i x_j \rho_{L_i L_j} \sigma_{L_i} \sigma_{L_j} \quad (11)$$

$$\sigma_{LV} = \sum_{i=1}^N \sum_{j=1}^M y_i x_j \rho_{V_i L_j} \sigma_{V_i} \sigma_{L_j} \quad (12)$$

Where $x_i = L_i / L$ is the proportion of losses from line i , $y_i = V_i / V$ is the proportion of assets from asset type i , $\rho_{V_i V_j}$ is the correlation between log asset type i and log asset type j , $\rho_{L_i L_j}$ is the correlation between log line i losses and log line j losses, $\rho_{V_i L_j}$ is the correlation between log asset type i and log line j losses, σ_{V_i} is the volatility of asset type i , and σ_{L_j} is the volatility of log line j losses

We aggregate each insurer's lines of business into four categories such as personal property, personal liability, commercial property and commercial liability line. We use NAIC quarterly time series data available from 1991-2002 to calculate underwriting return series. The quarterly underwriting return series are adjusted for seasonality using the U.S. Census Bureau's X11 procedure. The underwriting return series defined as the natural logarithm of the present value of incurred losses and loss adjustment expenses divided by the earned premium for each quarter.

As in Cummins et al. (2005), the asset portfolio is classified into seven categories: stocks, government bonds, corporate bonds, real estate, mortgages, cash and other invested assets, and non-invested assets. The quarterly estimates of the asset returns on the first six categories are obtained from the standard rate of return series. The return series for the other assets are calculated by the natural logarithm of the

¹⁷ As in Myers and Read (2001), we assume that the distribution of loss return series and asset return series is joint lognormal.

gross quarterly percentage change in the total market value of asset of the insurance industry net of the market value of the first six asset categories.

Finally, we can calculate the respective volatility and the respective correlation matrix for both asset portfolio returns and liability portfolio returns and between asset portfolio and liability portfolio returns using industry-wide quarterly data.

2.3.2. The Estimation of Myers-Read Insolvency Put Value and Marginal Capital Allocation

Myers and Read propose a capital allocation model based on an options pricing framework. A key element of their model is the value of the default put option. The underlying variables for the default option are the market value of assets (V) and the present value of loss liabilities (L). The amount of capital (S) can be expressed as $V - L$. Assuming with the limited liability, shareholders hold an option to put the default costs to the policyholders if the assets are insufficient to cover the loss liabilities. The insurer can declare bankruptcy if $L > V$ at the end of period. The default amount is $L - V$. Let D represent the market value of default amount, $D = PV[(Max(L - V, 0)]$. The default value, D is also called the insolvency put value. The value of default option is a function of the market value of assets, the present value of loss liabilities and the volatility of the asset-to-liability ratio: $D = f(V, L, \sigma)$.

Myers and Read are modeling a multiple-line insurance company. If an insurer writes M lines of business, the insurer's total losses are the sum of loss of each line ($L = \sum_{i=1}^M L_i$, where L_i =present value of loss liabilities for line i and M represents the number of lines of business). In this paper, assets are also classified into N categories,

$V = \sum_{i=1}^N V_i$, where V_i =the amount of asset of type i and N represents the number of asset categories.

As Myers and Read point out, if the aggregate losses and asset values are jointly lognormal distributed, the relevant measure of firm portfolio risk is the volatility of the asset to liability ratio (σ): $\sigma = \sqrt{\sigma_V^2 + \sigma_L^2 - 2\sigma_{LV}}$, where σ_V =the volatility of insurer's assets, σ_L =the volatility of insurer's loss liabilities, and σ_{LV} =the covariance of the natural logarithms of assets and losses values.

To calculate the default-value-to liability ratio, Myers and Read applied the following formula:

$$d = N\{z\} - (1+s)N\{z-\sigma\} \quad (13)$$

$$\text{where } z = \frac{-\log(1+s) + \sigma^2 / 2}{\sigma}$$

Myers-Read shows that marginal default values can be a marginal capital allocation base. Their marginal default values by line of business (d_i) is obtained by taking partial derivatives of insolvency put value, D with respect to loss liabilities for line i , L_i :

$$d_i = d + \left(\frac{\partial d}{\partial s}\right)(s_i - s) + \left(\frac{\partial d}{\partial \sigma}\right) \left(\frac{1}{\sigma} [(\sigma_{L_i L} - \sigma_L^2) - (\sigma_{L_i V} - \sigma_{LV})]\right) \quad (14)$$

According to their unique “add up” property, the insolvency put value for the company (D) can be obtained by the sum of products of line-by-line liabilities and marginal default values.

$$D = \sum_{i=1}^M L_i d_i \quad (15)$$

Myers and Read (2001) propose to allocate insurer’s surplus to each lines of insurance business to equalize marginal default values since insurer’s entire surplus is available to pay the claims from any specific policy or line of business where it is needed and policyholders have a preference for protection against default on their claims based on the insurer’s total amount of surplus. Assuming the same default value to liability ratio across all lines of insurance ($d_i = \partial D / \partial L_i = d$), Myers and Read marginal capital allocation by line of business (s_i) is derived by:

$$s_i = s - \left(\frac{\partial d}{\partial s}\right)^{-1} \left(\frac{\partial d}{\partial \sigma}\right) \left(\frac{1}{\sigma} [(\sigma_{L_i L} - \sigma_L^2) - (\sigma_{L_i V} - \sigma_{LV})]\right) \quad (16)$$

Where $s_i (= \partial S / \partial L_i)$ is the surplus allocated per dollar of loss liability in line i , $s (= S / L)$ is the insurer’s aggregate surplus-to-liability ratio, $d (= D / L)$ is the insurer’ insolvency put per dollar of total liabilities, σ is the volatility of the asset to liability ratio, $\partial d / \partial s$ is the partial derivative of d with respect to s (the option delta), $\partial d / \partial \sigma$ is the partial derivative of d with respect to volatility of the asset to liability ratio (the option vega), $\sigma_{L_i L}$ is the covariance of log losses in line i with log losses of

liability portfolio values, σ_{L_iV} is the covariance of log losses in line i with log assets portfolio values, σ_{LV} is the covariance of log losses of liability portfolio values with log assets portfolio values.

The important implication of Myers-Read's marginal capital allocation formula is that diversification by adding more lines of business that have low correlation with losses of other lines of business (or that have high correlation with asset portfolio returns) may reduce insurer's overall capital requirement.

Using estimated volatility and correlation matrix for both asset portfolio returns and liability portfolio returns, we can estimate both the ratio of marginal capital allocation-to-liability ($MCA_{i,g,t}$) and the ratio of insolvency put value-to-liability ($IPV_{g,t}$) that are used to test our hypothesis.

3. Hypotheses Formulation

A frequently stated motive for mergers and acquisition activity is a desire to diversify the firm by pooling uncorrelated risks. Most property-liability companies write multi-lines of insurance. The multi-line insurer may reduce insolvency risk by diversifying its exposures across lines of business or geographic locations, since the businesses in the portfolio coinsure one another. For instance, risk characteristics and loss variability of property insurance are likely to differ from those of liability insurance. Both property and liability insurance may have a function of offsetting underwriting risks each other. Therefore, diversification enables firm to reduce its overall underwriting risk and thus can lower the amount of capital that insurer should hold to support insurance risks if the lines of businesses are not perfectly correlated with one another (Merton and Perold, 1993).

An important implication of diversification effect is that a particular line that may have high capital requirement on a stand-alone basis but has offsetting risks with other lines of business could be valuable in the context of portfolio of businesses. Thus, the risk of the portfolio of businesses will be less than the sum of the stand-alone risks of the businesses, requiring less capital to hold to support uncertain events (Merton and Perold, 1993). Myers and Read (2001) show that if each line of business is assumed to be organized as a stand-alone firm, total surplus requirements for those lines increase because of loss of diversification. If we do not consider the effect of

diversification when allocating capital by lines of business, we may overestimate the cost of capital for that specific line, leading to overpricing of that risk. The marginal capital allocation formula proposed by Myers and Read(2001) illustrate that diversification by adding more lines of business with low covariability with the insurer's current loss portfolio (or high covariability of loss portfolio with asset portfolio) can decrease the capital requirements of the insurer and therefore will lead to more efficient use of capital. Perold (2001) also suggest that diversification across business segments diminish the firm's deadweight cost of risk capital. The present paper examines these insights. Accordingly, we hypothesize that diversification by M & A activity decreases the capital requirements (capital to liability ratio) of merging or acquiring insurer.

The primary implication of the option pricing model for insurance is that the price of insurance is inversely related to firm default risk (e.g., Cummins and Danzon, 1997; Phillips, Cummins and Allen, 1998). The firm default risk depends on the amount of capital retained by insurers relative to liabilities. As capital allocation literatures (e.g., Merton and Perold; 1993, Myers and Read; 2001, Perold; 2001, and Zanjani, 2002) point out, customers of financial intermediaries are strongly risk-averse to firm default risk and thus financial intermediaries have an incentive to reduce insolvency risk by holding more capital. As the amount of capital held increases, the frictional costs of holding capital increase due to capital market imperfections. Thus, insurers that properly manage the frictional costs of capital will have a competitive advantage in pricing. Insurers have a motivation to manage capital costs through M & A activity by engaging in a portfolio of businesses that more efficiently utilizes the capital of the firm, and thus can decrease insurance price. This provides a rationale for the hypothesis that M & A leads to lowering the price of insurance of newly formed insurer due to efficient use of capital. Moreover, since insolvency risk of newly formed insurer may be changed due to changes in capital requirement after M & A, the price of insurance will be affected by the changes in insolvency risk. Thus, we hypothesize that the changes in firm insolvency risk of merging insurer due to M & A are inversely related to changes in insurance price. This hypothesis is relevant to prior literature (e.g., Phillips, Cummins and Allen, 1998).

Theoretically, firms may benefit from diversification by exploiting economies of scale and scope, and by reducing expected costs of financial distress or bankruptcy.

Economies of scale refer to the reduction in cost per unit as output increases. Economies of scale can be accomplished through operational efficiencies. For example, newly formed insurers can reduce marginal cost of producing a good or service by sharing information systems, distribution channel, investments, and policyholder services. Thus, we hypothesize that M & A tends to decrease marginal costs of writing additional policies for the newly formed insurer.

In the classical theoretical paradigm of the perfect capital market with perfect information and without taxes, transaction costs and bankruptcy costs, the pricing of specific risks should be constant across all financial institutions and should not depend on the characteristics of an individual financial firm's portfolio. In reality, financial markets do not operate without frictions such as taxation, regulatory environment and asymmetric information between managers and outside investors. Because holding capital is costly due to these market frictions, financial institutions do not hold sufficient capital to eliminate all insolvency risk. When financial intermediaries have to raise capital externally, imperfect capital markets impose deadweight costs that must be covered by the cash flows of a business line. Therefore, as noted in the section 2, in order for insurers to survive in imperfect capital markets with frictions, insurance price by line of business should reflect firm capital structure, the covariance among lines of business and between asset and liability portfolios and the amount of marginal capital allocated to each line of business.

The recent empirical study by Cummins, Lin, Phillips (2005) provides evidence that insurance prices are directly related to the marginal capital allocations suggested by the Myers and Read (2001) model and also related to the covariability of losses across lines of insurance predicted by Froot and Stein (1998).

The present paper builds on this work by incorporating diversification effects through M&A activity of the insurers. Specifically, we hypothesize that variations of marginal capital allocation due to changes in the portfolio risk of an insurer through M & A activity are related to corresponding variations in prices of lines of business of newly formed insurer. This hypothesis is related to the proposition of Myers and Read (2001) and Zanjani (2002) that differences in marginal capital allocation by lines of business due to portfolio change by M & A activity generate price differences across lines of insurance.

4. Methodology

We begin by discussing the estimation of the price of insurance. Next, we discuss a matched-pair research method to identify the effect of M & A activity on the changes in the price of insurance. This section also specifies regression methodology that enables us to test the relationship between changes in insurance price, changes in marginal capital allocation, and insolvency put value changes due to M & A activity across lines of business in property-liability insurance. We also define other variables to be used in the regression model.

4.1. The Estimation of the Price of Insurance

We use the economic premium ratio as the price of insurance following the insurance literature (e.g., Cummins and Danzon, 1997; Phillips et al., 1998, and Cummins et al., 2005). The economic premium ratio for a line of insurance is defined as premiums written for the line divided by the present value of losses and loss adjustment expenses incurred. More precisely, the economic premium ratio is as follows:

$$EPR_{i,t} = \frac{NPW_{i,t} - DIV_{i,t} - EXP_{i,t}}{(NLI_{i,t} + LAE_{i,t}) \times PVF_{i,t}} \quad (18)$$

where $EPR_{i,t}$ = the economic premium ratio for line i, in year t

$NPW_{i,t}$ = net premium written for line i, in year t

$DIV_{i,t}$ = dividends to policyholders incurred for line i, in year t

$EXP_{i,t}$ = underwriting expense incurred for line i, in year t

$NLI_{i,t}$ = net loss incurred for line i, in year t

$LAE_{i,t}$ = net loss adjustment expense incurred for line i, in year t

$PVF_{i,t}$ = present value factor for line i, in year t

$$PVF = \sum_{t=1}^T w_t \left(\frac{1}{1+r_t} \right)^t \quad \text{where } w_t \text{ represents the proportion of losses}$$

and loss adjustment paid at time t with assumption of $0 < w_t \leq 1$, and

$\sum w_t = 1$. r_t is U.S Treasury spot rate at time t and T represents the number of periods in the payout tail.

We assume premiums are paid at the beginning of the year and the losses and loss adjustment expenses are paid at the end of the time period. Premiums are measured net of dividends to policyholders and underwriting expenses because the

purpose is focusing on the part of premiums that reimburse the insurer for bearing risks (Cummins et al., 2005). The cost of acquiring and underwriting both new and renewal insurance business is a substantial element of expenses for most property-liability insurers and also varies significantly across lines of business. The underwriting expense includes commissions to agents that are generally the largest portion of underwriting expenses.

Losses and loss adjustment expenses incurred are discounted based on two present value factors: (1) the pattern of loss and loss adjustment expense payment, and (2) the discount interest rate. The pattern of loss payment (payout tail) depends on the characteristics of lines of business that insurer writes and its claims handling procedures. For example, the losses of short-tail lines such as property insurance are fully developed or ultimately paid in one or two years. Long-tail liability claims, such as auto liabilities, are fully developed in three to five years, while medical malpractice and workers compensation may develop for ten years or longer. The payout tail proportions for each line of business and for each year of the sample period are estimated based on Schedule P of annual statement data using Taylor separation method (Taylor, 2000).

We also estimate U.S. Treasury spot rate (zero rate) curve from the constant maturity treasury data using bootstrap method. The present value factor for each year is calculated by summing up the estimated payout tail proportions divided by the estimated zero curves for the number of periods in the payout tail. Thus, the present value of losses and loss adjustment expenses incurred is obtained by multiplying the total losses and loss adjustment expenses by the present value factor. The economic premium is calculated separately for each insurer and for each year of the sample period. The present value factor calculated for each line and each year are shown in Figure 1. Figure 1 presents that the commercial liability lines are more heavily discounted than the personal property lines over the sample period, consistent with the view that commercial lines develop longer than short-tail lines.

4.2. A Matched-Pair Method

The pre-M & A and post-M & A statistics are compared to provide evidence regarding the effect of M & A activity on the changes of capital requirement and on the changes of insurance price of newly formed insurer. The objective of before-after comparison analysis is to investigate the principal issues addressed in the present

paper, i.e., whether M & A leads to reduction in capital requirement (capital-to-liability ratio), lowering the price of insurance.

To identify price changes that can be attributed to M & A, we also use a matched-pair method where each newly formed insurer's price is evaluated relative to the price of non-M & A control group insurer. For each year 1995 to 2004, we select control group insurer which operate in the same line of business as newly formed insurer and which are of approximately the same size in terms of premium written. Similar to Chamberlain and Tennyson (1998), each newly formed insurer is matched to non-M & A control group insurer based on its size and same line of business across all years analyzed. To isolate the effect of the M & A on price change, the benchmarked price measure is first identified by subtracting the insurance price of control group insurer from the price of newly formed insurer. The isolated effect of M & A on price change is detected by subtracting the pre-merger benchmarked price from the post-merger benchmarked price. If the M & A has no effect on price change, the difference between the pre-merger benchmarked price and the post-merger benchmarked price will be zero. It is tested whether the paired differences and the change in paired differences are statistically significantly different from zero.

4.3. Regression Analysis

To investigate empirically whether variations of marginal capital allocation and variation of insolvency risk of the newly formed insurer due to M & A activity are related to the pre-M & A and post-M & A variations in prices of lines of business, multivariate ordinary least squares(OLS) regression is employed. We regress changes in insurance price across lines of business on changes in marginal capital allocation, changes in overall default value, and other control variables using the following regression model.

$$\Delta EPR_{i,t} = \alpha_0 + \alpha_1 \Delta MCA_{i,t} + \alpha_2 \Delta IPV_{j,t} + \alpha'_k CON_{i,t} + v_{i,t} \quad (17)$$

Where $\Delta EPR_{i,t} = EPR_{i,t+1} - EPR_{i,t-1}$ ¹⁸

$EPR_{i,t}$ = the economic premium ratio for line i, in year t

$$\Delta MCA_{i,t} = MCA_{i,t+1} - MCA_{i,t-1}$$

$MCA_{i,t}$ = the marginal capital allocated-to-liability ratio for line i, in year t

$$\Delta IPV_{j,t} = IPV_{j,t+1} - IPV_{j,t-1}$$

¹⁸ The year t+1 indicates one year after M & A transaction and year t-1 one year prior to transaction.

$IPV_{j,t}$ = the insolvency put value-to-liability ratio for insurer j, in year t
 $CON_{i,t}$ = control variables for line i, in year t
 $V_{i,t}$ = error term for line i, in year t

Four lines of business are estimated separately: personal property lines of business, personal liability lines of business, commercial property lines of business, and commercial liability lines of business. Similar to Cummins, Lin, Phillips (2005), the marginal capital allocated-to-liability ratio is used in the regression to test whether the changes in marginal capital allocation across lines within the newly formed insurer are reflected in the changes in the price of lines of business. If diversification by M & A activity reduces the acquirer's capital-to-liability ratio across lines of business, the price of lines of business is predicted to decrease. However, if diversification leads to inefficient use of capital, the newly formed insurer should increase the amount of capital to satisfy overall capital requirements, raising the price of insurance after M & A. Thus, we expect positive relationship between the changes in the insurance price across lines of business and changes in marginal capital allocation.

As an alternative measure of insurer financial strength and to test the hypothesis that the changes in firm insolvency risk due to M & A are inversely related to changes in insurance price, we include insolvency put values calculated from Myers-Read (2001) methodology. We predict changes in price are negatively related to the changes in insolvency put values, consistent with Phillips et al. (1998), Zanjani (2002), and Cummins et al. (2005).

The underwriting expense ratio measured by firm's overall underwriting expenses scaled by net premium written is included as a proxy for marginal cost for writing additional policies. Since M & A tends to decrease marginal costs of writing additional policies for the newly formed insurer because of economies of scale, we expect the changes in the underwriting expense ratio are positively related to the changes in the price of insurance.

Since large firms are likely to be more diversified and better accessible to capital markets than smaller firms, large firms should require relatively lower capital to achieve a given level of insolvency risk and thus may demand lower price. The natural log of firm assets is used as a proxy for firm size. We expect a negative relationship between changes in firm size and changes in the price of insurance.

We include the ownership form variable set equal to one for mutual firm and to zero otherwise. Mutuals eliminate the owner-policyholder conflict because policyholders are both customers and owners. However, benefits from control of owner-policyholder conflict are offset by less efficient control of owner-manager conflict (Mayers and Smith, 2001). The owner-manager conflict is more severe in the mutual insurer than in the stock firms since mutual managers are not well monitored in capital markets as compared to managers of stock insurers. Because cost of controlling management in mutual insurer is greater than in stock firms, mutual insurers should be more prevalent in lines of insurance where lower managerial discretion is required. In other words, mutuals have a comparative advantage in writing business lines with less underwriting risk, requiring less capitalization. Thus, the expected sign on this variable is negative.

A dummy variable is included equal to one if the firm is an unaffiliated single company and zero otherwise. Approximately one-third of the insurers in our sample are not affiliates of groups. The remainder is members of groups with common ownership and control. The managers of an unaffiliated company are likely to be more risk averse because group insurers may be able to diversify underwriting risk across member companies in a more efficient manner than unaffiliated single firms. Because an unaffiliated company tends to engage in less risky activities to avoid insolvency risk and may hold more capital, the expected sign on this variable is positive.

5. Data and Sample Selection

Annual financial statement data for U.S. property-liability insurance companies are obtained from the National Association of Insurance Commissioners (NAIC). This study focuses on mergers and acquisitions in the U.S. property-liability insurance industry over the sample period 1995-2004. The initial samples of M & A are identified through list of Best's Insurance Reports-Property/Casualty. We investigate each of these M &A related insurers through NAIC demographic files to identify insurance company codes and then cross-checked the list of M &A related insurers from Best's Insurance Reports against NAIC demographic files. Those M &A related insurers which could not be verified in NAIC demographic files are excluded from the sample. Thus, our final list of M &A involved insurers should exist both in NAIC demographic files and in the Best's Insurance Reports.

Some sample selection criteria are imposed to ensure that insurance firms analyzed are actively engaged in the writing insurance contracts as ongoing concerns, and thus, reported financial data are meaningful measures of insurer price and capital structure. Accordingly, the insurers that report positive values for premiums written, surplus and total admitted assets are included in our initial sample. Because we are unable to estimate values for some key variables such as economic premium ratio for those insurance companies that report non-positive values, they are excluded. Mergers and acquisitions of shell, inactive or run-off companies are excluded from the sample since the focus of the study is on the viable operating entities. We also omit insurers that were retired, or put into liquidation or receivership at merger and acquisition or within two years thereafter.

To implement Myers-Read capital allocation, we aggregate each insurer's lines of business into four categories: personal property lines of business, personal liability lines of business, commercial property lines of business, and commercial liability lines of business.¹⁹

We also utilize the NAIC by-line quarterly data (1991-2002) to estimate underwriting returns which are used to obtain estimates of industry-wide volatilities and correlation matrix between the asset and liability portfolios. The quarterly time series of returns of asset classes are obtained from the standard rate of return series: Stocks- the total return on the Standard & Poor's 500 stock index; government bond- the Lehman Brothers intermediate term total return; corporate bond-Moody's corporate bond total return; real estate-the National Association of Real Estate Investment Trusts (NAREIT) total return; mortgages-the Merrill Lynch mortgage backed securities total return; and cash and other invested assets-30 day U.S. Treasury bill rate.

6. Empirical Results

This section presents the results of empirical analysis. We first discuss the economic values of assets and liabilities for the U.S. property-liability insurance industry and illustrate Myers-Read capital allocations and insolvency put values. We

¹⁹ Personal property lines of business include Homeowners, Farmowners, Earthquake, and Auto Physical Damage. Personal liability line includes Private Passenger Auto Liability. Commercial property lines include Fire, Allied Lines, Commercial Multiple Peril, Mortgage Guaranty, Inland Marine, Financial Guaranty, Group Accident and Health, Credit and Other Accident and Health, Fidelity, Surety, Burglary and Theft, Credit. Commercial liability lines include Medical Malpractice, Other Liability, Product Liability, Workers' Compensation, Ocean Marine, Commercial Auto Liability, Aircraft, Boiler and Machinery, International, Reinsurance.

then report summary statistics for the newly formed insurers, comparing significant differences in means of variables of pre- and post M & A. This section also discusses the results of a matched-pair method and concludes by presenting regression results.

6.1. Summary Statistics

The number of insurers and the economic value of assets of the U.S. property-liability insurance industry for the sample period 1995-2004 are presented in the table 1.1. The number of insurers has remained relatively unvarying even though the insurance industry is undergoing significant wave of merger and acquisition activity. The reason is due to the fact that many M & A transactions involve groups buying and selling insurers that remain in operating after the transaction. Another reason is that the numbers of firms that withdraw from the market due to merger have been partially offset by the formation of new insurers (Cummins, Tennyson, and Weiss, 1999).

The economic value of assets is defined as the book value of total assets minus the book value of stocks, government bonds, and corporate bonds plus the market value of stocks, government bonds, and corporate bonds. Assets such as stocks, government bonds, and corporate bonds are adjusted to market values based on NAIC statutory accounting standards. However, other assets are reported at NAIC annual statement book values. Table 1.1 shows yearly and average values of several asset classes. Government bonds in the industry averages 35.7 percent of total economic assets, whereas stocks and corporate bonds account for 23.0 and 15.7 percent, respectively. Cash and short-term investments tend to be around 7 percent. Other assets including reinsurance recoverable on loss and loss adjustment expense payments, receivable from subsidiaries and affiliates, and agent's balances or uncollected premiums averages around 17 percent.

Table 1.2 shows the economic value of liabilities and equity for the U.S. property-liability insurance industry. The reserves for each line of business are adjusted to the present values by discounting the expected future loss cash flows with the estimated U.S. Treasury spot-rate curve. The payout tail proportions for each line of business and for each year of the sample period are estimated based on Schedule P of annual statement data using Taylor separation method (Taylor, 2000). Other liabilities are defined as total liabilities of the industry minus reserves for unpaid loss and loss adjustment expenses of commercial liability, commercial property, personal liability, and personal property after discounting. The commercial liability reserves

account for a significant proportion of total unpaid loss reserves. The economic equity is 37 percent of total economic assets on average. Notably, the amount of equity capital in the industry has increased from 33.4 percent in 2002 to 36.4 percent in 2004 because insurers may increase holding capital to avoid insolvency risk following a large loss shock such as 9/11.

The industry-wide volatility and correlation matrix that are determined by the quarterly time series of returns of seven asset classes and of the underwriting returns of four aggregated insurance lines are estimated as shown in Table 2.1, 2.2, and 2.3. Of the ten pair-wise correlations between returns of four insurance lines, the pairs of commercial liability and personal liability and the pairs of commercial property and personal property show the highest positive correlations with 87.6 and 50.7 percent, respectively. High correlations between them may be justified since their businesses are similar in nature. The correlation between personal property and personal liability is 6.6 percent. It can be argued that personal property lines that cover damage to static property are less likely to be correlated with personal liability line that provides coverage for third-party bodily injuries due to auto accidents. Personal property lines among four lines of business have higher volatility with 19.9 percent, reflecting the greater exposure to large losses such as hurricane and earthquake.

Table 2.2 displays the correlation matrix for asset and liability portfolios. Both commercial and personal property lines are inversely correlated with most asset returns, consistent with Cummins, Lin, and Phillips (2005). The returns of stocks have negative correlations with the returns of all of four aggregated lines, while the returns of government bonds are positively correlated with both commercial liability, 13.4 percent correlation and personal liability lines, 26.2 percent correlation, but are negatively correlated with both commercial property, -15.3 percent and personal property lines, -27.1 percent, implying that investment in government bonds provide a hedge against losses in liability lines. Stocks among asset classes show the highest volatility, 15.8 percent, consistent with common perception. The correlations between asset classes are presented in the table 2.3. The returns of government bonds and mortgages are strongly positively related each other, 92.5 percent correlations. Insurers may have an incentive to reduce asset portfolio risk by investing both in stocks and government bonds since both stocks and government bonds returns are inversely related each other, -28.3 percent correlations.

Table3 provides an illustration of Myers-Read insolvency put value and capital allocations for the U.S. property-liability insurance industry. In the present paper, we measure insurer's default risk by Myers-Read insolvency put value. The default-to-liability ratio is calculated to obtain the insolvency put value. For instance, the average default value of industry during the period, 1995-2004 is \$31.03 million or 4.67E-05 percent of the present values of industry liabilities. We allocate the economic capital across the four aggregated insurance lines and other liabilities based on the economic values of assets and liabilities in Table1.1 and 1.2, and the estimation of industry-wide volatility and correlations shown in Table2.1, 2.2, and 2.3. The capital-to-liability ratio indicates the marginal capital requirement for each line. In other words, the marginal increase in the present value of losses for the line requires the marginal increase in capital requirement for that line. On average, the capital-to-liability ratio for commercial liability, commercial property, personal liability, and personal property line is 123 percent, 54 percent, 43 percent, and 58 percent, respectively, compared to 23 percent of other liabilities. This result is consistent with Myers-Read predictions that the marginal capital allocation partly depends on the respective volatility of loss return series since their loss return volatility shows 18.5, 17.7, 14.9, 19.8 and 0.09 percent, respectively presented in Table2.1. The right column of Table3 shows that the amount of total economic capital is 100 percent allocated by lines of business.

The number of M & A transactions and the number of sample ultimately used in the analysis of the economic premium ratio and marginal capital allocation are reported in Table4. We initially identified 367 firms that involved in mergers and acquisitions during the period, 1995-2004 through a search of Best's Insurance Reports. We first exclude any acquirer that merges with a shell company (34 firms) and reinsurers (17 firms). Also excluded from the sample were insurers that merge into inactive firms, or put into liquidation within one or two years after M & A.²⁰ Some insurers are involved in multiple M & A transactions at same years or within two years before or after the transactions. We omit them to prevent double counting in the sample. The 40 firms are eliminated because the company codes of those merging or acquiring firms are not found in the NAIC demographic files. We exclude 51 insurers since some data used to calculate several financial ratios before or after M &

²⁰ For example, some insurers merge into inactive firms in other states even merged firms do not operate with no assets or premiums because acquiring firms may want to move their headquarters to other states.

A are not available. The 38 firms that exhibit negative premiums, negative economic equity, or unusual financial ratios are also excluded because we are unable to estimate the economic premium ratio and calculate Myers-Read capital allocation. A total of 101 insurers are eventually used in the regression after applying our sample selection criteria.

6.2. Comparisons of Pre- and Post M & A Statistics and a Matched-Pair Result

Table 5 reports statistics on the pre- and post-M & A variables for merging and acquiring insurers for which both pre- and post-M & A data are available. Table 5 exhibits several statistically significant differences in means of values of pre- and post M & A insurers. Consistent with our hypothesis that diversification due to M & A activity leads to reduction in capital requirement of the newly formed insurers, the overall firm capital-liability ratio on average decreases significantly from 1.368 to 1.197 after M & A. Notably, the post-M & A marginal capital requirements (line capital-to-liability ratio) are significantly lower than pre-M & A marginal capital requirements for commercial liability line (from 0.893 to 0.838) and commercial property line (from 1.901 to 1.681), suggesting that surplus requirements for those lines decrease because of diversification benefits. However, there are no statistically significant differences in the changes of firm portfolio risk and insolvency put per one dollar of total liabilities due to M & A.

Our univariate results also provide some evidence consistent with the argument that insurer that can reduce capital requirement by engaging in a portfolio of businesses in which returns are not perfectly correlated has a competitive advantage in pricing. As shown in Table 5, the economic premium ratio decreases significantly from 1.291 to 1.143 for commercial liability line and from 1.356 to 1.246 for commercial property line after M & A activity. These findings suggest that the change in capital requirement (capital-to-liability ratio) due to M & A activity is directly reflected in insurance price change. The relative capital to liability ratios measured by the line specific marginal capital requirements (line capital-to-liability ratio) scaled by the overall firm capital-to-liability ratio show significant differences for all lines except personal property line.

Table 5 provides some evidence that merging and acquiring insurers take advantage of scale economies. The underwriting expenses to net premium written ratio decrease significantly from 0.318 to 0.307, indicating that newly formed insurer

is able to reduce acquisition or administrative costs by sharing physical inputs such as offices, computer hardware.

Table 5 also demonstrates that underwriting leverage measured by premium written relative to firm overall equity capital changes significantly for each line. It makes a sense that the post-M & A underwriting leverage for commercial liability and personal liability line is significantly worse than that of pre- M & A since the capital requirement decreases and premium volume increases after M & A. As expected, the amounts of assets, liabilities, equity capital and net premium written by lines are significantly different from pre- M & A to post-M & A.

Table 6 provides the results of price change of newly formed insurers relative to control group insurers. The table shows average price of pre-merger, post-merger and the difference between pre-merger and post-merger. Based on the difference between the pre-merger benchmarked price and the post-merger benchmarked price, table 6 shows that insurance price decreases significantly after M & A in the commercial property line. There are no statistically significant differences in the change of insurance price before and after M & A from other lines.

6.3. Regression Results

To examine whether the changes in marginal capital allocation and insolvency risk due to M & A activity are reflected in the changes of price of insurance across lines of business, we estimate multivariate ordinary least squares(OLS) regression based on the M & A sample of U.S. property-liability insurance industry. The change in each variable is measured by differencing the value of one year prior to M & A from the value of one year after M & A.

The regression results shown in Table 7 provide evidence that the changes in marginal capital allocation are positively related to the changes in the price of insurance. Consistent with Cummins, Lin, Phillips (2005), the coefficient of the change of marginal capital allocation is positive and statistically significant in commercial liability and personal liability lines, indicating that efficient use of capital due to M & A enables newly formed insurers to provide lower price for their product. However, the marginal capital allocation is not statistically significant in both commercial property and personal property lines. We include the firm's overall capital-to-liability ratio and relative capital-to-liability ratio (measured by the ratio of

the marginal capital allocated to liability ratio to the firm's overall capital-to-liability ratio), they are not statistically significant.

The results provide support for hypothesis that the changes in firm insolvency put value of newly formed insurer are inversely related to changes in insurance price in commercial property and personal property lines, consistent with the prior literature (e.g., Cummins and Danzon, 1997; Phillips, Cummins and Allen, 1998; Cummins, Lin, Phillips, 2005). As Cummins et al.(2005) point out, this suggest that lower capitalization is related to higher insolvency risk, resulting in lower price.

The regression model includes control variables. Some of them are consistent with expectations while others are not statistically significant. The coefficient of the change of underwriting expense ratio is positive and statistically significant in commercial property and commercial liability lines, implying that decrease in underwriting expense ratio due to M & A reduce the price of insurance. This suggests that newly formed insurer may take advantage of economies of scale by sharing offices and computer systems. The changes in firm size is negative and statistically significant only in personal liability line, consistent with the expectation that large firms may demand relatively lower price because of lower capital requirement due to diversification benefits. However, this variable is not statistically significant in other lines. The dummy variable for mutual ownership form has a negative sign and is statistically significant only in commercial property line, suggesting that mutuals have lower prices because they have a comparative advantage in writing less risky lines such as fire, allied lines, and commercial multiple peril. The dummy variable for unaffiliated firm is negative and significant only in commercial property line, inconsistent with expectation of positive sign. This possibly suggest that an unaffiliated company is likely to engage in writing less risky lines such as commercial property line, they may demand lower price not to lose their customers.

7. Conclusions

Froot and Stein (1998) and the capital allocation literature (e.g., Myers and Read, 2001 and Zanjani, 2002) predict the prices of illiquid risks depend upon the firm's capital structure, the covariance of an individual line of insurance relative to the riskiness of firm's entire portfolio, and marginal capital allocated to the line of business. The recent empirical study by Cummins, Lin, Phillips (2005) provides

evidence that insurance prices are directly related to the marginal capital allocations and also related to the covariability of losses across lines of insurance.

We build upon this work by testing whether large changes in the portfolios of an insurer, through M&A activity, are reflected in capital requirement and prices of the newly formed insurer. Myers and Read demonstrate theoretically that diversification by adding more lines of business with low covariability with the insurer's current loss portfolio (or high covariability of loss portfolio with asset portfolio) can decrease the overall capital requirements of the insurer and therefore will lead to more efficient use of capital. This paper provides empirical tests of this insight using the sample of U.S. property-liability insurers that engaged in M & A activity over the period 1995-2004. Specifically, we investigate whether firms that engage in M & A activity in an attempt to acquire a portfolio of businesses utilize the capital of the firm more efficiently and whether changes in the price of insurance across lines in the newly formed insurer reflect not only the lower overall capital costs but also new capital allocation by lines of business.

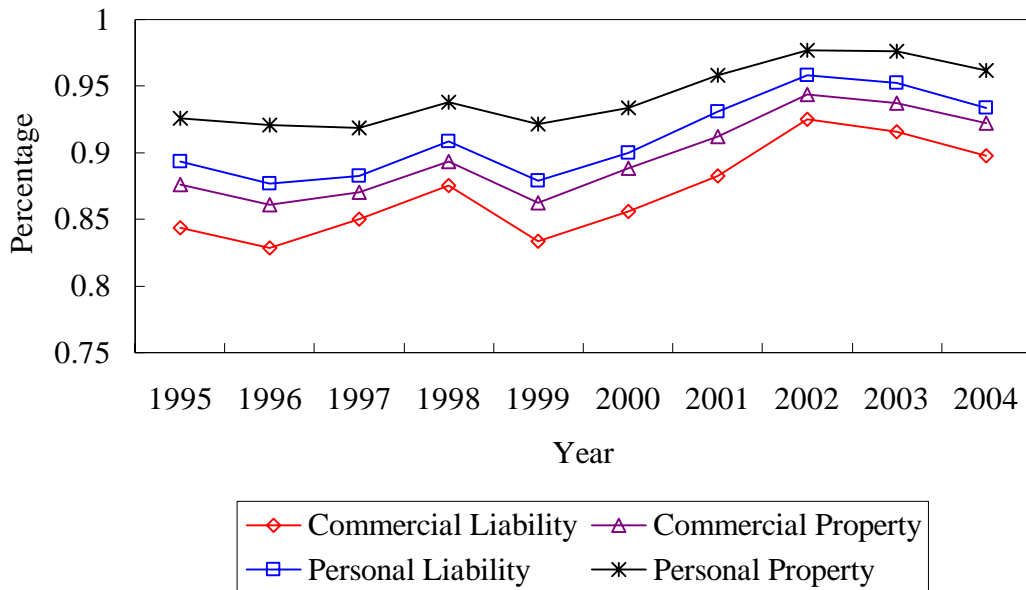
To provide support regarding the hypotheses, we compared pre-M & A and post-M & A statistics where economic premium ratio is calculated by the net premium written scaled by the present value of incurred losses for each line and where Myers-Read's marginal capital allocation is obtained by taking partial derivatives of firm's insolvency put value with respect to the present value of loss liabilities for each line. We allocate insurer's capital to each line of business to equalize marginal default values across lines. The results provide support for the hypothesis that M & A leads to reduction in capital requirement (capital-to-liability ratio), lowering the price of insurance for the newly formed insurer.

To test hypotheses, we also conduct regressions where dependent variable is the change in price for each line and where explanatory variables include the change in firm insolvency put value and the change in marginal capital allocation for each line. The regression results provide some evidence for the hypothesis that the changes in firm insolvency risk are inversely related to changes in insurance price in commercial property and personal property lines. We also find that the changes in marginal capital allocation are positively related to the changes in the price of insurance in commercial liability and personal liability lines.

The overall conclusion is that M & A leads to efficient use of capital in the U.S. property-liability insurance industry and insurance price reflects lower overall

capital costs as well as new marginal capital allocation by lines of business within the newly formed firm. The results can provide insurance regulators with some implications to assess capital adequacy after M & A activity and show the importance of incorporating insolvency risk and marginal capital costs in pricing lines of insurance business. This work can be extended to develop more sophisticated econometric method to isolate the M & A effects on the change of capital requirement and price change. We need to control for potential biases resulting from changes between pre- and post-M & A because other factors that are not related to M & A may affect price change.

**Figure 1. Present Value Factor By Line of Business
For the Estimation of Economic Premium Ratio**



The Figure1 presents the present value factors that are used to calculate the present value of loss and loss adjustment expense incurred. The economic premium ratio for a line of insurance is defined as premiums written for the line divided by the present value of losses and loss adjustment expenses incurred. Losses and loss adjustment expenses incurred are discounted based on two present value factors: (1) the pattern of loss and loss adjustment expense payment, and (2) the discount interest rate. The payout tail proportions for each line of business and for each year of the sample period are estimated based on Schedule P of annual statement data using Taylor separation method (Taylor, 2000). We also estimate U.S. Treasury spot rate (zero rate) curve from the constant maturity treasury data using bootstrap method. The present value factor for each year is calculated by summing up the estimated payout tail proportions divided by the estimated zero curves for the number of periods in the payout tail. The present value of losses and loss adjustment expenses incurred is obtained by multiplying the total losses and loss adjustment expenses incurred by the present value factor.

Table 1.1. Economic Value of Assets for the U.S. Property-Liability Insurance Industry, 1995-2004 (Unit: \$Millions)

Year	Number of Company	Stocks	%	Government Bonds	%	Corporate Bonds	%	Real Estate	%	Mortgages	%	Cash + Other Invested	%	Other Assets	%	Economic Assets
1995	2688	186,129	0.209	379,726	0.427	121,060	0.136	9,273	0.010	2,857	0.003	56,209	0.063	134,403	0.151	889,661
1996	2708	201,990	0.217	386,251	0.416	135,770	0.146	9,623	0.010	2,544	0.003	56,683	0.061	136,613	0.147	929,469
1997	2721	257,936	0.251	403,769	0.392	154,531	0.150	9,472	0.009	2,315	0.002	59,788	0.058	141,695	0.138	1,029,506
1998	2757	282,565	0.262	393,125	0.365	166,333	0.154	9,188	0.009	2,045	0.002	69,853	0.065	154,241	0.143	1,077,355
1999	2708	293,569	0.277	349,494	0.330	169,096	0.160	9,532	0.009	2,197	0.002	66,569	0.063	168,031	0.159	1,058,491
2000	2679	267,784	0.254	343,561	0.326	177,461	0.168	9,646	0.009	1,645	0.002	81,568	0.077	171,725	0.163	1,053,393
2001	2699	249,362	0.226	344,673	0.312	191,549	0.173	9,329	0.008	2,554	0.002	83,502	0.076	224,514	0.203	1,105,485
2002	2680	229,278	0.193	389,675	0.328	196,025	0.165	9,532	0.008	2,588	0.002	112,345	0.095	248,327	0.209	1,187,773
2003	2699	273,158	0.205	436,372	0.328	216,052	0.162	9,280	0.007	2,715	0.002	127,536	0.096	267,290	0.201	1,332,406
2004	2727	301,135	0.207	497,056	0.342	228,786	0.158	9,329	0.006	3,108	0.002	130,726	0.090	281,947	0.194	1,452,089
Average	2706	254,291	0.230	392,370	0.357	175,666	0.157	9,420	0.009	2,457	0.002	84,478	0.074	192,879	0.171	1,111,563

Table shows the economic value of assets for the U.S. property-liability insurance industry over the sample period 1995-2004. Assets are adjusted to market values based on NAIC statutory accounting standards. Stocks, government bonds, and corporate bonds are reported at market values. However, other assets are described at NAIC annual statement book values. The economic value of assets is defined as the book value of total assets minus the book value of stocks, government bonds, and corporate bonds plus the market value of stocks, government bonds, and corporate bonds.

Table 1.2. Economic Value of Liabilities and Equity for the U.S. Property-Liability Insurance Industry, 1995-2004 (Unit: \$Millions)

Year	Number of Company	Commercial Liability Reserves	%	Commercial Property Reserves	%	Personal Liability Reserves	%	Personal Property Reserves	%	Other Liabilities	%	Economic Liabilities	%	Economic Equity Capital	%	Economic Liab+Equity Capital
1995	2688	201,820	0.227	43,462	0.049	64,168	0.072	12,766	0.014	258,986	0.291	581,204	0.653	308,456	0.347	889,661
1996	2708	205,276	0.221	44,397	0.048	63,529	0.068	13,025	0.014	274,150	0.295	600,378	0.646	329,090	0.354	929,469
1997	2721	203,047	0.197	45,194	0.044	63,242	0.061	12,424	0.012	285,505	0.277	609,414	0.592	420,091	0.408	1,029,506
1998	2757	208,093	0.193	49,222	0.046	64,199	0.060	13,893	0.013	293,866	0.273	629,276	0.584	448,078	0.416	1,077,355
1999	2708	188,292	0.178	49,153	0.046	61,968	0.059	14,241	0.013	322,932	0.305	636,588	0.601	421,902	0.399	1,058,491
2000	2679	186,409	0.177	49,519	0.047	64,480	0.061	15,433	0.015	330,511	0.314	646,355	0.614	407,038	0.386	1,053,393
2001	2699	197,159	0.178	57,726	0.052	68,202	0.062	17,361	0.016	381,402	0.345	721,852	0.653	383,632	0.347	1,105,485
2002	2680	220,915	0.186	60,768	0.051	73,913	0.062	19,494	0.016	416,455	0.351	791,547	0.666	396,225	0.334	1,187,773
2003	2699	240,739	0.181	62,907	0.047	76,631	0.058	20,908	0.016	464,060	0.348	865,247	0.649	467,158	0.351	1,332,406
2004	2727	259,577	0.179	67,856	0.047	77,215	0.053	21,893	0.015	497,633	0.343	924,176	0.636	527,912	0.364	1,452,089
Avg.	2706	211,133	0.192	53,020	0.048	67,755	0.062	16,144	0.014	352,550	0.314	703,657	0.633	407,906	0.367	1,111,563

Table shows the economic value of liabilities and equity for the U.S. property-liability insurance industry over the sample period 1995-2004. The reserves for each line of business are adjusted to the present values by discounting the expected future loss cash flows with the estimated U.S. Treasury spot-rate curve. The expected future loss cash flows are based on the pattern of loss and loss adjustment expense payment. Other liabilities are defined as total liabilities of the industry minus all reserves of commercial liability, commercial property, personal liability, and personal property after discounting.

Table2.1. Liability Volatility and Correlation Matrix, 1991-2002

Liability Class	Commercial Liability	Commercial Property	Personal Liability	Personal Property	Other Liabilities	Annual Volatility
Commercial Liability	1.0000	0.2911	0.8760	0.1752	0.1049	0.1854
Commercial Property	0.2911	1.0000	0.2123	0.5071	-0.2837	0.1770
Personal Liability	0.8760	0.2123	1.0000	0.0655	0.2035	0.1496
Personal Property	0.1752	0.5071	0.0655	1.0000	-0.1124	0.1988
Other Liabilities	0.1049	-0.2837	0.2035	-0.1124	1.0000	0.0999

Table2.2. Asset and Liability Correlation Matrix, 1991-2002

Asset & Liability Class	Commercial Liability	Commercial Property	Personal Liability	Personal Property	Other Liabilities	Annual Volatility
Stocks	-0.3247	-0.1646	-0.4237	-0.1960	-0.1784	0.1583
Government Bonds	0.1336	-0.1529	0.2622	-0.2707	0.1189	0.0371
Corporate Bonds	0.0639	-0.3539	0.0015	-0.2690	-0.0894	0.0683
Real Estate	0.0579	0.0250	0.1084	0.1181	-0.0321	0.1215
Mortgages	0.0927	-0.2396	0.2421	-0.3736	0.1424	0.0343
Cash & Others Invested	-0.6334	-0.2414	-0.4564	-0.2567	-0.0470	0.0064
Other Assets	0.1497	0.2804	0.1718	0.0256	0.2598	0.0708

Table2.3. Asset Correlation Matrix, 1991-2002

Asset Class	Stocks	Government Bonds	Corporate Bonds	Real Estate	Mortgage	Cash & Others Inv.	Other Assets
Stocks	1.0000	-0.2833	0.5570	0.2946	-0.0907	0.1952	-0.1972
Government Bonds	-0.2833	1.0000	-0.0146	0.0493	0.9250	0.1966	-0.0141
Corporate Bonds	0.5570	-0.0146	1.0000	0.2662	0.1354	0.1013	0.0767
Real Estate	0.2946	0.0493	0.2662	1.0000	0.1247	0.0684	-0.1591
Mortgages	-0.0907	0.9250	0.1354	0.1247	1.0000	0.2809	0.0051
Cash & Others Invested	0.1952	0.1966	0.1013	0.0684	0.2809	1.0000	0.0307
Other Assets	-0.1972	-0.0141	0.0767	-0.1591	0.0051	0.0307	1.0000

Table2.1, 2.2, and 2.3 provide industry-wide volatilities and correlation matrix that are determined by the quarterly time series of returns of seven asset classes and of the underwriting returns of four aggregated insurance lines over the period, 1991-2002. The quarterly estimates of the asset returns on the first six categories are obtained from the standard rate of return series (Stocks- S & P 500 index; government bond-Lehman Brothers intermediate term total return; corporate bond-Moody's corporate bond total return; real estate-NAREIT total return; mortgages-Merrill Lynch mortgage backed securities total return; cash and others invested-30-day U.S. Treasury bill rate). The return series for other assets are calculated by the natural logarithm of the gross quarterly percentage change in the total market value of asset of the insurance industry net of the market value of the first six asset categories. The quarterly underwriting return series adjusted for seasonality with the U.S. Census Bureau's X11 procedure are defined as the natural logarithm of the present value of incurred losses and loss adjustment expenses divided by the earned premium for each quarter.

Table3. Insolvency Put Value and Capital Allocations for the U.S. Property-Liability Insurance Industry, 1995-2004 (Unit: \$Millions)

Year	Default-to-Liability		Capital-to-Liability Ratio					The Amount of Capital Allocated by Lines and % of Economic Capital										Economic Capital
	Default-to-Liab Ratio	Insolvency Put Value	CL	CP	PL	PP	OL	CL	%	CP	%	PL	%	PP	%	OL	%	
1995	7.41E-05	43.08	1.10	0.42	0.36	0.45	0.15	222,639	0.72	18,133	0.06	22,839	0.07	5,720	0.02	39,123	0.13	308,456
1996	5.29E-05	31.76	1.14	0.44	0.37	0.47	0.17	234,414	0.71	19,508	0.06	23,347	0.07	6,158	0.02	45,672	0.14	329,090
1997	5.18E-05	31.57	1.44	0.57	0.47	0.61	0.23	291,561	0.69	25,858	0.06	29,999	0.07	7,581	0.02	65,094	0.16	420,091
1998	3.73E-05	23.46	1.48	0.61	0.49	0.64	0.24	307,076	0.68	29,898	0.07	31,462	0.07	8,893	0.02	70,748	0.16	448,078
1999	4.77E-05	30.35	1.37	0.63	0.51	0.67	0.29	257,211	0.61	31,082	0.07	31,362	0.07	9,520	0.02	92,726	0.22	421,902
2000	6.53E-05	42.23	1.30	0.61	0.50	0.65	0.28	243,010	0.59	30,284	0.07	32,006	0.08	10,079	0.03	91,657	0.23	407,038
2001	6.62E-05	47.82	1.10	0.55	0.43	0.58	0.25	217,284	0.56	31,659	0.08	29,049	0.08	10,021	0.03	95,618	0.25	383,632
2002	4.09E-05	32.36	1.05	0.50	0.39	0.54	0.22	233,024	0.58	30,468	0.08	28,798	0.07	10,484	0.03	93,451	0.24	396,225
2003	1.98E-05	17.12	1.14	0.53	0.41	0.58	0.25	274,538	0.58	33,608	0.07	31,563	0.07	12,184	0.03	115,265	0.25	467,158
2004	1.14E-05	10.57	1.21	0.56	0.42	0.61	0.26	314,274	0.59	38,237	0.07	32,382	0.06	13,385	0.03	129,634	0.25	527,912
Avg.	4.67E-05	31.03	1.23	0.54	0.43	0.58	0.23	259,692	0.64	28,631	0.07	29,134	0.07	9,363	0.02	81,086	0.20	407,906

The table displays insolvency put value for the U.S. property-liability insurance industry and amount of economic capital allocated across five lines of business based on Myers and Read (2001) methodology. CL represents commercial liability, CP commercial property, PL personal property, PP personal property, and OL other liabilities. The column of default-to-liability ratio is calculated to obtain insolvency put value. The column of capital-to-liability ratio shows the marginal capital requirement for each line in response to the marginal increase in the present value of losses for the line.

Table4. Number of M & A Transactions and Sample Selection Criteria, 1995-2004

	Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
M & A transactions and sample selection criteria												
M & A initially identified in Best's Reports		39	46	39	31	36	32	31	34	50	29	367
Less Merge with shell target		1	5	5	5	4	0	3	0	7	4	34
Reinsurer M & A		2	1	7	1	1	1	0	1	3	0	17
In liquidation after M & A							1	1	1	1		4
Remerge within 2 years			3		1		2		2	1		9
Merge with life insurer				1				1				2
Merge into inactive insurer		1	1			1			1	1		5
Involve in multiple M & A		4	5	4	4	3	4	3	9	12	18	66
Not found on NAIC database		5	7	6	4	4	7	1	1	2	3	40
No data pre or post M & A		6	7	9	8	5	3	5	6	2	0	51
Negative premium/negative equity		5	4	3	2	4	4	6	1	5	4	38
Sample used in the regression analysis		15	13	4	6	14	10	11	12	16	0	101

Data source: Best's Insurance Reports and NAIC database

Table5. Comparison of Pre- and Post-M & A Statistics for Merging/Acquiring Insurers, 1995-2004 Averages

Variables	Pre-M & A			Post-M & A	
	Mean	Std. Dev.		Mean	Std. Dev.
Dependent Variables					
Economic Premium Ratio					
Commercial Liability (CL)	1.291	0.778	**	1.143	0.464
Commercial Property (CP)	1.356	0.674	**	1.246	0.521
Personal Liability (PL)	1.101	0.473		1.099	0.505
Personal Property (PP)	1.015	0.342		1.050	0.454
Explanatory Variables					
Total Assets (millions)	\$997	\$3,184	***	\$1,124	\$3,477
Total Liabilities (millions)	\$645	\$2,088	***	\$755	\$2,403
Equity Capital (millions)	\$351	\$1,167	***	\$368	\$1,129
CL Net Premium Written (millions)	\$135	\$480	**	\$130	\$512
CP Net Premium Written (millions)	\$76	\$227	***	\$93	\$268
PL Net Premium Written (millions)	\$30	\$179		\$42	\$282
PP Net Premium Written (millions)	\$35	\$168	***	\$56	\$317
CL Line Capital-to-Liability Ratio	0.893	1.343	**	0.838	1.141
CP Line Capital-to-Liability Ratio	1.901	4.181	**	1.681	3.932
PL Line Capital-to-Liability Ratio	0.353	1.022		0.429	1.036
PP Line Capital-to-Liability Ratio	1.304	2.634		1.147	2.411
Firm Capital-to-Liability Ratio	1.368	2.260	**	1.197	1.885
Firm Capital-to-Asset Ratio	0.435	0.200		0.421	0.199
Relative CL Line Capital-to-Liability Ratio	1.223	0.920	*	1.230	0.845
Relative CP Line Capital-to-Liability Ratio	0.941	0.745	*	0.916	0.932
Relative PL Line Capital-to-Liability Ratio	0.611	0.822	*	0.604	0.849
Relative PP Line Capital-to-Liability Ratio	1.088	0.870		1.147	2.411
Insolvency Put per Total Liabilities	0.002	0.007		0.004	0.021
Firm Portfolio Risk	0.229	0.962		0.136	0.031
CL Line Premium Written to Equity Ratio	0.408	0.758	**	0.425	1.542
CP Line Premium Written to Equity Ratio	0.350	0.385		0.340	0.437
PL Line Premium Written to Equity Ratio	0.197	0.314	*	0.198	0.362
PP Line Premium Written to Equity Ratio	0.389	0.455		0.400	0.444
Underwriting Expenses to Premium Written Ratio	0.318	0.144	**	0.307	0.183
Unaffiliated Single Company	0.292	0.457		0.286	0.454
Mutual Company	0.542	0.501		0.551	0.500

Note: ***, **, * indicate statistical significance at 1, 5, and 10 percent level, respectively. 101 observations.

Table6. Comparison of Insurance Price Change of Newly Formed Insurers to Control Group Insurer: 1995-2004

	Commercial Liability			Commercial Property			Personal Liability			Personal Property		
	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change
Newly Formed Firms												
Mean	1.291	1.143	-0.148	1.356	1.246	-0.109	1.101	1.099	-0.002	1.015	1.050	0.035
S.D	0.778	0.464	0.838	0.674	0.521	0.722	0.473	0.505	0.679	0.342	0.454	0.469
Median	1.114	1.093	-0.018	1.244	1.205	-0.092	1.081	1.036	0.000	1.014	1.019	-0.019
Non M & A Firms												
Mean	1.274	1.281	0.007	1.366	1.438	0.072	1.123	1.032	-0.091	1.142	1.122	-0.019
S.D	0.803	0.483	0.874	0.621	0.563	0.677	0.362	0.272	0.467	0.405	0.433	0.443
Median	1.167	1.182	0.016	1.270	1.349	0.096	1.092	1.025	-0.046	1.082	1.111	-0.022
Newly-Non M & A												
Mean	-0.098	-0.061	-0.037	-0.010	-0.191	-0.181	-0.022	0.067	0.089	-0.127	-0.073	0.054
S.D	0.819	0.657	1.062	0.809	0.747	0.982	0.556	0.603	0.732	0.527	0.623	0.692
Median	-0.03	-0.011	-0.088	-0.025	-0.101	-0.109	-0.079	0.014	0.028	-0.094	-0.09	-0.033
T Value	-1.14	-0.88	0.33	-0.13	-2.58	-1.85	-0.30	0.86	0.94	-2.23	-1.08	0.73
Sign Test	-2.50	-1.50	-4.50	-3.00	-8.00	-11.00	-4.00	1.00	0.00	-11.50	-7.50	-1.50
Firm Numbers	90	90	90	101	101	101	60	60	60	86	86	86

Pre refers to insurance price of one year prior to M & A transaction and Post refers to insurance price of one year after M & A transaction. Newly-Non M & A means paired differences between the price of newly-formed insurer and the price of non-M & A insurer (control group insurer). T value reports the statistic to test the null hypothesis that the mean paired difference is zero. Sign test shows the statistic to test null hypothesis that same numbers of positive and negative paired difference is present.

Table7. Regression Results: 1995-2004

$$\Delta EPR_{i,t} = \alpha_0 + \alpha_1 \Delta MCA_{i,t} + \alpha_2 \Delta IPV_{j,t} + \alpha'_k CON_{i,t} + v_{i,t}$$

Variable	<u>Commercial Property</u>		<u>Commercial Liability</u>		<u>Personal Property</u>		<u>Personal Liability</u>	
	Coefficient	T Statistic	Coefficient	T Statistic	Coefficient	T Statistic	Coefficient	T Statistic
Intercept	-0.153	-0.24	-0.004	-0.01	0.138	0.29	0.761	0.82
Change in insolvency put value	-18.631	-3.18	-38.722	-0.83	-32.003	-6.13	2.362	0.21
Change in marginal capital requirement	0.066	0.05	0.019	2.22	-0.013	-0.61	0.581	3.86
Change in underwriting expense ratio	1.185	3.42	0.134	1.76	0.007	0.07	-0.987	-0.81
Change in firm size(log of assets)	-0.016	-0.51	-0.055	-0.62	0.002	0.02	-0.415	-2.63
Mutual ownership form	-0.385	-2.71	0.201	0.46	-0.066	-0.13	-0.765	-0.81
Non-affiliated firm	-0.324	-1.81	-0.202	-0.36	-0.468	-0.78	-0.769	-0.83
Adjusted R-square	0.22		0.19		0.55		0.69	
Observations	101		52		52		36	

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