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Capital and risk in property-liability insurance markets

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Abstract

This paper investigates the capital and portfolio risk decisions of property-liability insurance firms. A theoretical model based on option pricing theory is developed which predicts a positive relationship between insurer capital and risk, as firms balance these two factors to achieve their desired overall insolvency risk. The implications of the model are then tested empirically using a simultaneous equations methodology. The results support the predictions of the model. They also provide evidence that managerial incentives play a role in determining capital and risk in insurance markets. The findings have significant implications for insurance solvency regulation.

JEL classification: G22; G32

Keywords: Capital; Portfolio risk; Property-liability insurance; Insolvency risk

1. Introduction

Insolvency rates in the property-liability insurance industry have increased dramatically in recent years. The number of insolvencies increased from 10 per year during the period 1969–1983 to more than 30 per year from 1984–1992, while annual assessments by insurance guaranty funds rose from $40 to $500 million per year (Cummins et al., 1994). The higher insolvency costs have focused

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renewed attention on insurance regulation. Insurance is regulated by the states, and insurance regulators have been criticized as lax and ineffectual in monitoring solvency (U.S., House of Representatives, 1990; U.S., General Accounting Office, 1989, 1991). In response to these criticisms, the National Association of Insurance Commissioners (NAIC) has implemented a number of reforms in state solvency regulation (see Klein, 1995). Reforms include the introduction of an accreditation system for state insurance departments as well as requirements for independent CPA audits of insurer financial statements and actuarial certification of loss reserves. Perhaps the most important regulatory reform has been the adoption of risk-based capital (RBC) systems for both life-health and property-liability insurers. Proposals are under consideration for more stringent regulation of insurer asset portfolio risk.

The NAIC risk-based capital system significantly increases statutory minimum capital standards and imposes more rigorous closure rules. [1] The objective of the system is to minimize the costs of insolvencies to guaranty funds and the public, by rehabilitating or closing undercapitalized insurers before significant deficits are incurred (Klein, 1995). [2] The effectiveness of RBC and the need for additional asset risk regulation will depend upon the response by insurers to the more stringent capital standards and closure rules. The objective of this paper is to provide evidence on this issue by analyzing the relationship between capital and risk in the property-liability insurance industry. We present a theoretical discussion of the issue, followed by empirical tests.

Option pricing analysis predicts that the existence of flat-premium guaranty fund insurance creates an incentive for insurers to engage in excessive risk-taking

[1] The NAIC's risk-based capital (RBC) system gives regulators the mandate and the authority to exercise prompt corrective action to minimize the costs of insurer insolvencies. The formula consists of proportionate charges that are multiplied by balance sheet and income statement variables and summed to obtain each insurer's risk-based capital. Regulatory action is triggered if an insurer's actual capital falls below 200 percent of its risk-based capital. There are four levels of regulatory action, with the most stringent being regulatory seizure of insurers whose capital levels fall below 70 percent of their risk-based capital. The principal charges in the property-liability insurance formula are for underwriting risk, asset risk, credit risk, and growth risk. Underwriting risk is the risk that loss payments will be greater than the expected losses allowed for in the premiums charged to policyholders. The underwriting risk charge accounts for about two-thirds of industry-wide risk-based capital. Asset risk charges, to account for the risk of bond defaults and stock price fluctuations, represent about one-fifth of total risk-based capital. There is presently no charge for interest rate risk. The remainder of industry-wide risk-based capital is about equally divided between credit and growth risk-based capital. Credit risk-based capital reflects the risk that insurers will not be able to collect accounts receivable, primarily from reinsurers and agents, and growth risk-based capital assesses a charge for excessive growth in premiums (for more details, see Cummins et al., 1994). The system went into effect for the 1994 annual regulatory financial statements.

[2] Earlier detection and prompt corrective action could have prevented many of the largest and most widely publicized failures of the 1980s (U.S., House of Representatives, 1990).

(e.g., Merton, 1977). However, several hypotheses have been advanced in the banking literature suggesting that other elements of market structure may mitigate this incentive and lead financial institutions to prefer finite levels of risk and leverage that are below the regulatory maximums. We briefly review the most important of these hypotheses and discuss their relevance to insurance. We also propose another reason that insurers may prefer finite risk and leverage, motivated by the observation that insurance guaranty fund protection is less complete than that provided by bank deposit insurance. [3] We argue that buyers of insurance have an incentive to monitor the solvency of insurers and that the demand for safe insurance leads to an equilibrium level of solvency risk in insurance markets, i.e., insurers are hypothesized to choose risk levels and capitalization to achieve target solvency levels in response to buyer demands for safety. [4]

The relationship between capital and risk is analyzed empirically using a simultaneous equations model. The results of the estimation support the hypothesis that capital and risk are directly related in property-liability insurance. This is consistent with prior research showing that the majority of insurers hold levels of equity capital well above the regulatory minima. [5]

The principal policy implication of these results is that the imposition of risk-based capital standards is not likely to induce an increase in risk-taking among well-capitalized insurers. Thus, as long as the risk-based capital system results in regulators taking prompt corrective action against weak insurers, adequately capitalized insurers should be permitted to operate without additional restrictions on their asset and liability portfolio choices, such as stronger rules to control investment risk. However, because weak insurers are likely to have an incentive to take additional risk (Harrington and Danzon, 1994), regulators should focus on monitoring solvency and taking prompt corrective action against insurers whose financial condition is risky or deteriorating. Restrictions on portfolio risk

[3] Insurance guaranty funds impose a maximum amount that can be collected per claim (usually $300000), and the protection of many funds does not extend to important types of commercial insurance. In addition, claimants often experience delays and incur significant transactions costs in collecting their claims. The funds are state mandated, but there is no government financial backing (benefit payments are funded by assessments on solvent insurers). Hence, the protection provided by the funds inspires less public confidence than deposit insurance.

[4] While we focus on buyers of insurance here, it should be mentioned that insurance companies also have an incentive to monitor each other, since guaranty funds are funded by assessments on solvent insurers. This is similar to the situation faced by banks under some state deposit insurance systems prior to the creation of FDIC insurance. As described by Calomiris (1992), this method of funding deposit insurance led to significant monitoring within the banking industry.

[5] In 1991 only about 8 percent of firms in the property-liability insurance industry held equity capital below 200 percent of their risk-based capital, and more than 50 percent of firms held capital of at least 500 percent of risk-based capital (Cummins et al., 1995). An even smaller proportion of insurers fell below the previous capital minima.

could be imposed on such insurers if necessary under the RBC rules without restricting well-capitalized firms.

There have been few previous studies of insurer risk-taking. Michaelsen and Goshay (1967), Hammond et al. (1976), and Harrington and Nelson (1986) all find some degree of support for the hypothesis that insurers with higher portfolio risk operate with lower leverage ratios (measured in most cases by the ratio of net premiums written to equity). However, these studies are limited in that they either have no theoretical foundations or assume that insurers maximize utility. All three studies use a single annual cross-section to estimate regressions based on crude proxies for leverage and portfolio risk. Our hypotheses are based on a more appropriate theoretical structure, the risky debt model of the firm, and our measures of leverage and risk are those implied by the theoretical model.

The insurance article most similar to ours is Cummins and Danzon (1995). Cummins and Danzon also use an option model to develop hypotheses, but focus on price and flows of external capital rather than leverage and risk. The study most comparable to ours in the banking literature is Shrieves and Dahl (1992), and our findings are consistent with theirs.

The paper is organized as follows: Section 2 presents the theoretical model, formulates hypotheses, and discusses alternative views of insurance market equilibrium. Section 3 specifies the empirical model and the variables to be used in the estimation. Sample selection, methodology, and the results are discussed in Section 4, and Section 5 concludes the paper.

2. Theoretical background and hypothesis formulation

This section first presents our theoretical model. We then briefly review the other theoretical arguments about capital and risk that have been advanced in the literature and summarize our hypotheses.

2.1. Solvency in insurance markets

We analyze insurance pricing and solvency using the option model of the firm. In this model insurance is viewed as corporate debt that is discounted by the market to reflect insolvency risk. The option model has been widely used in both the banking and insurance literature (e.g., Merton, 1977; Sharpe, 1978; Furlong and Keeley, 1989; Ronn and Verma, 1989; Doherty and Garven, 1986; Cummins, 1988). Our approach differs from the prior literature in that we hypothesize a demand function for insurance that is decreasing in insolvency risk.

The insurer is assumed to begin operations at time 0 with equity capital of E. It issues insurance policies (liabilities) with nominal value of L. Assets ($A = L + E$)

and liabilities are assumed to follow geometric diffusion processes:

$$\frac{\mathrm{d}A}{A} = \alpha_A \,\mathrm{d}t + \sigma_A \,\mathrm{d}z_A$$

$$\frac{\mathrm{d}L}{L} = \alpha_L \,\mathrm{d}t + \sigma_L \,\mathrm{d}z_L \tag{1}$$

where $\mathrm{d}z_L \mathrm{d}z_A = \rho\,\mathrm{d}t$, α_A, α_L are the instantaneous expected changes in assets and liabilities, respectively, σ_A, σ_L are the instantaneous standard deviations of assets and liabilities, and ρ is the instantaneous correlation coefficient between assets and liabilities.

Insurance claims are paid at time 1, with the policyholders receiving $\min[A_1, L_1] = L_1 - \max[L_1 - A_1, 0]$, where A_1 and L_1 are the realized values of the asset and liability processes at the maturity date. The fair competitive price of insurance at any time before the maturity date of the liabilities is given by the riskless present value of the liability claims less the value of a put option on the assets of the firm with strike price equal to the nominal value of the liabilities, i.e.,

$$B(A,L,\tau;r,\sigma) = L\mathrm{e}^{-r\tau} - P(A,L,\tau;r,\sigma) = L[\mathrm{e}^{-r\tau} - p(x,1,\tau;r,\sigma)] \tag{2}$$

where $B(A,L,\tau;r,\sigma)$ is the fair competitive value of the firm's insurance liabilities evaluated at time interval $\tau \in [0,1]$ from the maturity date, with interest parameter r and risk parameter σ (A and L are the known values of the state variables at time $t = 1 - \tau$, where time 1 is the maturity date and t is the present), $P(A,L,\tau;r,\sigma)$ is a put option on assets (A) with exercise price (L), evaluated at time interval τ prior to maturity, $p(x,1,\tau;r,\sigma)$ is a put option on state variable x with strike price 1, r is the risk-free rate, r_f, minus the inflation rate for insurance liabilities, r_L, σ^2 is the insurer's risk parameter ($= \sigma_A^2 + \sigma_L^2 - 2\rho\sigma_A\sigma_L$), and x is the asset to liability ratio ($= A/L$).

In the second line of (2), the homogeneity property of the option model has been used to express the value of insurance liabilities in terms of the asset-to-liability ratio, x.

In this model, the expected costs of insolvency are expressed in terms of the insolvency put option, i.e., $Lp(x,1,\tau;r,\sigma)$. This is a standard Black–Scholes European option, with maturity at the next regulatory audit date. There are two endogenous variables that affect the value of the put, the asset-to-liability ratio and the risk parameter σ. The put value varies inversely with the asset-to-liability ratio and directly with the risk parameter. By choosing appropriate values for these two parameters, the insurer can achieve its target level of expected insolvency costs. We assume that insurers do not exploit the relationship between the put value and risk to expropriate value from policyholders after policies are issued. Instead, insurers seek to operate as ongoing entities in order to take advantage of experience gained in underwriting and claims settlement activities. Such experience (private information) as well as long-term customer relationships permits insurers to develop franchise values that would be diminished in the event of reputation loss.

We also assume that policyholders are averse to insolvency risk, i.e., they do not view insurance solely as a financial asset but purchase insurance in order to mitigate the risk of loss. We believe this to be a reasonable assumption about property-liability insurance markets. Individual policyholders are known to be risk averse, and they typically cannot hedge most types of risk in any other way than by purchasing insurance. Small and medium size businesses are likely to care about solvency risk for similar reasons (Greenwald and Stiglitz, 1990). The demand for insurance by widely held corporations is a more complicated issue because such firms may have little to gain in terms of diversification by purchasing insurance. Nevertheless, corporations do purchase substantial amounts of insurance for various reasons (see Mayers and Smith, 1982), and there is considerable anecdotal evidence that they prefer to deal with financially sound insurers (e.g., Calise, 1992).

We formalize our assumption about insurance demand by introducing an insurance demand function $Q(\pi, p(x,\sigma))$, where Q is quantity demanded, π the unit price of insurance, and $p(x,\sigma)$ is a reduced notation for the insolvency put per dollar of liabilities, $p(x,1,\tau;r,\sigma)$. It is assumed that demand is inversely related to both the unit price and the insolvency put, $\partial Q/\partial\pi = Q_\pi < 0$ and $\partial Q/\partial p = Q_p < 0$. Thus, buyers are assumed to have full information about insurer insolvency risk and to adjust their demand for insurance accordingly. The assumption that $Q_\pi < 0$ implies that demand for insurance is not infinitely elastic. Evidence consistent with this hypothesis has been presented in D'Arcy and Doherty (1991), Cummins and Danzon (1995), and Berger et al. (1989). The usual rationale is the existence of switching or search costs. [6] We assume that the unit price is set by the regulator such that $(\pi - e^{-r\tau} + p(x,\sigma)) > 0$.

With these assumptions, the insurer's optimization problem is to maximize profits by choosing its level of insolvency risk, $p(x,\sigma)$:

$$\text{Maximize: } Q(\pi, p(x,\sigma))[\pi - e^{-r\tau} + p(x,\sigma)] \tag{3}$$

[6] Among the reasons for switch costs is the existence of private information that is acquired when customers deal with the same insurer over a period of years. Insurers acquire private information on the risk characteristics of policyholders, which is an increasing function of the amount of time the relationship exists (D'Arcy and Doherty, 1991). Likewise, because claims are infrequent events for most buyers, information on insurer claims service quality also is acquired only over a period of time. Both types of private information are destroyed if the policyholder switches companies.

The first-order condition for a maximum with respect to insolvency risk is: [7]

$$Q_p[\pi - e^{-r\tau} + p(x,\sigma)] + Q = 0 \tag{4}$$

Eq. (4) implies that an equilibrium level of insolvency risk will exist in insurance markets, induced by the insolvency-aversion of insurance buyers. [8] This level of insolvency risk is consistent with an infinite number of combinations of σ and x. In practice, the equilibrium pair (σ, x) will be determined by factors such as the correlation between asset and liability returns and the cost of capital to insurers. It is easy to demonstrate that $dx/d\sigma > 0$, i.e., that an increase in the insurer's risk parameter is accompanied by an increase in capitalization (represented by the asset-to-liability ratio, x). Thus, we hypothesize the existence of a direct relationship between risk and capitalization based on our model.

2.2. Guaranty funds and risk-based capital

Policyholders are protected against loss due to insurer insolvencies by state guaranty funds, which raise money to pay claims by levying assessments on solvent insurers. The assessments are flat rather than being risk-based, a feature that has been identified as a potential source of moral hazard in insurance markets (Cummins, 1988). If guaranty fund protection is complete, i.e., if claimants against insolvent insurers are paid in full, then policyholders will be indifferent regarding default risk and insurers will have an incentive to increase equity at the expense of the guaranty funds by taking more risk. However, guaranty fund protection is less than complete. All states place limits on the amount that can be recovered per claim (usually \$300 000), and certain types of insurance such as that purchased by large businesses is exempted from coverage by many guaranty funds. Furthermore, claim payments from guaranty funds are usually delayed when compared to payments from solvent insurers, and claimants are likely to incur transactions costs in securing payment from the fund. Policyholders are not reimbursed for claims settlement and risk management services that would have been performed by the insurer if the firm had not become insolvent.

The effect of incomplete guaranty funds can be modelled by introducing a parameter θ representing the proportion of the put value that is actually incurred as a loss by the policyholder in the event of insolvency, where $0 < \theta < 1$. The demand function in the optimization problem (3) becomes $Q(\pi, \theta p(x))$, but the profit term, $\pi - e^{-r\tau} + p(x)$, is unchanged because the insurer still receives the

[7] We assume that the second-order condition for a maximum is satisfied. A sufficient but not necessary condition for this is that $Q_{pp} = \partial^2 Q / \partial p^2 < 0$, implying that demand eventually goes to zero as p increases. This condition seems descriptive of behavior in real-world insurance markets.

[8] Depending upon the level of π and the functional relationship between Q and p, it is possible that no equilibrium exists, i.e., that the market will fail. However, since our empirical work is based on a viable market, it seems reasonable to conduct the theoretical analysis under the assumption that market failure is not present. The potential for market failure is also an interesting topic for analysis, but is beyond the scope of the present paper.

full benefit of the put. Thus, the elasticity of demand with respect to the put declines (in absolute value) to $\theta Q_p p/Q$ for any given put value and the equilibrium put value increases. However, as long as $\theta > 0$, the predicted relationship between risk and capitalization still holds.

Risk-based capital establishes a maximum value for the put. As we have seen, with incomplete guaranty fund protection, insurers still have an incentive to offer insurance that is not infinitely risky. The objective of the RBC system should be to establish a maximum put value sufficiently low to enable regulators to take timely action against insurers in deteriorating financial condition. If this maximum put value is significantly below the level established by the market for the majority of insurers, these firms can be permitted to operate without additional restrictions on their asset and liability portfolio choices. However, as financial condition deteriorates, the incentive to increase risk to exploit the insolvency put also increases (Furlong and Keeley, 1989; Keeley and Furlong, 1990; Harrington and Danzon, 1994). Thus, regulators should focus on monitoring solvency and should take prompt corrective action against insurers that reach regulatory action boundaries. Since regulatory action is likely to result in some loss of franchise value, by consistently taking prompt corrective action regulators can provide an additional incentive for insurers to operate safely.

If the risk-based capital system measures insolvency risk with error, the RBC system will have to establish a lower maximum put value to effectively protect the guaranty funds (Flannery, 1991). This will increase the proportion of insurers in the vicinity of the regulatory boundary and allow weak insurers more opportunity to take additional risk in the areas where the risk-based capital measurement system is weakest. [9] Thus, regulators should also devote attention to improving the accuracy of the RBC formula and other solvency monitoring techniques.

2.3. Cost-based hypotheses

Shrieves and Dahl (1992) discuss another factor that may affect the relationship between risk and capitalization for banks and other financial institutions. Even if market solvency incentives are inadequate, the implicit and explicit costs of regulation could force insurers to balance leverage and risk, creating de facto risk-based capital standards (see Buser et al., 1981). We attempt to discriminate between our model and the regulatory costs hypothesis by using a regulatory stringency variable, discussed below. Shrieves and Dahl (1992) found support for the regulatory costs hypothesis in their study of the banking industry.

Insurers may also prefer to operate at finite levels of leverage and risk to avoid bankruptcy costs. These costs include explicit bankruptcy costs as well as implicit costs such as the loss of franchise value.

[9] For further analysis of measurement error, see Flannery (1991).

2.4. Agency theory and the managerial discretion hypothesis

Agency theory implies that a misalignment of the incentives of owners and managers allows managers to pursue strategies different from those preferred by owners. Managers may be hesitant to pursue risky strategies, even if doing so would increase the market value of owners equity, because optimizing their long-run compensation depends upon the survival of the insurer. Thus, a higher degree of separation between ownership and management may be associated with lower firm risk.

Another agency-theoretic hypothesis that yields similar predictions is the managerial discretion hypothesis (Mayers and Smith, 1981, 1988). Mayers and Smith argue that organizational forms where owner–manager or policyholder–manager conflicts are strong will be less successful in activities that require relatively high degrees of managerial discretion because managerial discretion provides more opportunities for managers to pursue their own interests at the expense of other stakeholders in the firm (owners and/or policyholders). They provide evidence that mutual insurers, where owners (the policyholders) have little control over management, are more successful in lines of insurance which are characterized by standardized policies and good actuarial tables and hence do not require significant managerial discretion. On the other hand, stock insurers are more successful in selling more risky and individualized lines of insurance and in operating over wider geographical areas.

Our stock company sample is sufficiently rich to permit us to test the relationship between risk and the separation of ownership and management. The sample includes publicly traded insurers as well as closely held firms that are owned by management and closely held firms owned by parties other than management. Owner–manager conflicts are expected to be smallest in closely held firms owned by managers and largest (among stock insurers) in publicly traded firms, with closely held firms owned by other parties providing an intermediate case. Agency theory implies that risk-taking should be inversely related to the degree of separation of ownership from management, represented by the three sets of firms in our sample. The predictions are that closely held firms will adopt more risky strategies than widely held firms and that firms closely held by management may take more risk than those closely held by other parties. A countervailing hypothesis, proposed in Fama and Jensen (1983), is that closely held corporations will take less risk than widely held firms because the owners of such firms concentrate a high proportion of their wealth in the closely held venture and thus are not optimally diversified. If this effect dominates the managerial discretion effect, we might observe closely held firms taking less risk than widely held firms. [10]

[10] Saunders et al. (1990) provide evidence that stockholder controlled banks take more risk than banks controlled by managers who do not have an equity interest in the institution.

3. Equation specification and variable definitions

This section specifies the empirical model used to test the hypotheses developed in the preceding section. We begin by specifying a two equation model of risk levels and capitalization of property-liability insurers and then define the variables to be used in the estimation.

3.1. The model

We specify a model that allows us to test for the relationship between capitalization and risk levels in property-liability insurance. Because adjustment of capital and risk may not be complete within any given period, the model we use is general enough to allow us to test for the presence of partial adjustments. Rejection of the partial adjustment hypothesis would imply the absence of adjustment lags in this market. Partial adjustment models have been used previously to model changes in bank capital ratios by Mingo (1975), Dietrich and James (1983), Marcus (1983), Wall and Peterson (1988), Dahl and Shrieves (1990), and Shrieves and Dahl (1992) and have been used to model changes in bank portfolio risk by Shrieves and Dahl (1992).

The model discussed in the previous section implies that the insurer seeks to attain an optimal value of the insolvency put through its choice of the two endogenous parameters, the asset-to-liability ratio, x, and the risk parameter, σ. Choosing x is equivalent to choosing the capital-to-asset ratio, E/A, and we use the latter variable in our analysis, to be consistent with the prior literature (e.g., Shrieves and Dahl, 1992). Insurers can change the capital ratio and risk parameter by issuing stock, paying dividends, and restructuring their asset and liability portfolios. Capital and risk also can be affected by exogenous factors such as catastrophic losses and changes in liability rules. Thus, changes in capital and risk can be written as follows:

$$\Delta CAP_{jt} = \Delta CAP_{jt}^{D} + \epsilon_{jt}^{C} \tag{5}$$

$$\Delta SIGMA_{jt} = \Delta SIGMA_{jt}^{D} + \epsilon_{jt}^{S} \tag{6}$$

where ΔCAP_{jt} is the change in the capital-to-asset ratio of firm j from time $t-1$ to t, $\Delta SIGMA_{jt}$ the change in the portfolio risk of firm j from time $t-1$ to t, ΔCAP_{jt}^{D} the endogenously determined adjustment to capital from $t-1$ to t, $\Delta SIGMA_{jt}^{D}$ the endogenously determined adjustment to portfolio risk from time $t-1$ to t, and ϵ_{jt}^{C}, ϵ_{jt}^{S} the exogenous adjustments to capital and portfolio risk from time $t-1$ to t. In the partial adjustment model, the endogenous components of the changes in the capital-to-asset ratio and risk are proportional to the difference between the insurer's target values of these variables and their values at the end of the preceding period:

$$\Delta CAP_{jt} = \alpha\left[CAP_{jt}^{*} - CAP_{j,t-1}\right] + \epsilon_{jt}^{C} \tag{7}$$

$$\Delta SIGMA_{jt} = \beta\left[SIGMA_{jt}^{*} - SIGMA_{j,t-1}\right] + \epsilon_{jt}^{S} \tag{8}$$

where CAP_{jt}^* is the insurer's target capital-to-asset ratio at time t, $SIGMA_{jt}^*$ the insurer's target portfolio risk at time t, and α, β adjustment coefficients.

Partial adjustment of capital to its target level would be consistent with the existence of information asymmetries between owners and managers. Like other firms, insurers' primary source of equity is retained earnings. Insurers raise new external capital primarily to replace capital that has been depleted by loss or investment shocks. New capital issuance is likely to occur with a lag following a shock if information asymmetries between insurers and investors are more severe following a shock. For example, investors may be more uncertain about the valuation of loss reserves following a shock and therefore reluctant to supply capital. On the other hand, insurers raised substantial amounts of new equity following liability insurance loss shocks in 1984–1985 (Cummins and Danzon, 1995), suggesting that information asymmetries are not necessarily a barrier to capital flows. Our tests of the partial adjustment hypothesis provide additional evidence on this issue.

To complete the model, the target capital ratio and portfolio risk are specified as follows:

$$CAP_{jt}^* = a'X_{jt}^C + u_{jt}^C \tag{9}$$

$$SIGMA_{jt}^* = b'X_{jt}^S + u_{jt}^S \tag{10}$$

where a, b are parameter vectors, X_{jt}^C, X_{jt}^S vectors of explanatory variables, and u_{jt}^C, u_{jt}^S random disturbance terms. The option model implies that the optimal level of capital is determined in part by the level of sigma and that the optimal level of sigma is determined in part by the level of capital. Hence, the levels of risk and capital appear in the vectors of explanatory variables in Eq. (9) and (10), respectively.

Substituting Eq. (9) and (10) into Eq. (7) and (8) and rearranging yields the equation specifications used in estimating the model:

$$CAP_{jt} = \alpha a'X_{jt}^C + (1-\alpha)CAP_{j,t-1} + \gamma_{jt}^C \tag{11}$$

$$SIGMA_{jt} = \beta b'X_{jt}^S + (1-\beta)SIGMA_{j,t-1} + \gamma_{jt}^S \tag{12}$$

where

$$\gamma_{jt}^C = \alpha u_{jt}^C + \epsilon_{jt}^C$$

$$\gamma_{jt}^S = \beta u_{jt}^S + \epsilon_{jt}^S \tag{13}$$

The variables are defined in the following section.

3.2. Variable definitions

Most of the data for our empirical analysis are obtained from the A.M. Best Company property-liability data tapes. The annual statements filed with state regulators are the original source of the Best data. We have made adjustments to the data to reflect generally accepted accounting principles (GAAP). [11]

3.2.1. Endogenous variables

The capital-to-asset ratio is the ratio of statutory capital plus GAAP adjustments to total assets. Capital is adjusted for pre-paid acquisition costs by adding the product of the expense ratio (the ratio of underwriting expenses to net premiums written) and the unearned premium reserve to statutory surplus. [12]

The risk parameter is taken from the option model, i.e., $\sigma^2 = \sigma_A^2 + \sigma_L^2 - 2\rho\sigma_A\sigma_L$. To quantify this variable, estimates are needed of the asset and liability volatilities and the correlation coefficient between the asset and liability processes. The asset and liability portfolios of each insurer were treated as separate, correlated mutual funds. Return data on assets were obtained as $r_{it} = \ln(I_{it}/I_{i,t-1})$, where I_{it} is total return index for asset category i in quarter t from Ibbotson Associates (1991). Accumulation rates on losses in various insurance lines were obtained similarly as $s_{jt} = \ln(L_{jt}/L_{j,t-1})$, where L_{jt} is losses and loss adjustment expenses incurred in line j and quarter t from the A.M. Best quarterly by-line data base. [13]

The asset and liability return series were used to create a quarterly return series

[11] The use of book data in insurance research is the standard approach because of the limited number of insurers with publicly traded equity. Book value data is also frequently used in banking research (e.g., Shrieves and Dahl, 1992). However, the authors acknowledge that this is a limitation of the research. Insurers do not report their bonds at market values, and do not discount their reserves. In addition, book values cannot incorporate intangible assets such as 'franchise value.' Thus, the use of book value data is not ideal. An interesting avenue for future research would be to collect and analyze market value data on insurers with traded equity.

[12] In insurance accounting terminology, equity capital is called policyholders' surplus or surplus. We also add to surplus the reserve for unauthorized reinsurance and the excess of statutory over statement reserves, also standard GAAP adjustments.

[13] For the purposes of computing sigma, assets were grouped into four categories: short-term debt, intermediate-term debt, long-term debt, and corporate equities. The rationale is that insurers are heavily invested in short-term debt instruments, bonds, and stock. To proxy for the returns in the four asset categories, we used, respectively, total returns on 90-day U.S. treasury bills, intermediate-term government bonds, long-term government bonds, and common stock from Ibbotson Associates (1991). In 1990, bonds and short-term debt instruments accounted for 66.7 percent of the total assets of property-liability insurers and corporate equities accounted for 14.4 percent of assets. Most of the remainder of the portfolio is in non-invested assets such as receivables from agents and reinsurers. Unlike life insurers, property-liability insurers hold only a small fraction of their assets in mortgages and real estate (about 2 percent in these categories combined), and a high proportion of the industry's bond portfolio (e.g., 98 percent in 1990) is in investment grade bonds (A.M. Best Company, 1991). The bond portfolio consists of about 30 percent U.S. government bonds, 45 percent state and local government bonds, and 25 percent corporate bonds. The liability categories used were fire, allied lines, homeowners and farmowners multiple peril, commercial multiple peril, inland marine, workers' compensation, medical malpractice, other liability, auto liability, auto physical damage, and all other lines. The period over which returns were calculated, dictated by the availability of the A.M. Best quarterly loss data, was 1975–1989.

for each of the NT observations in the sample, based on the asset and liability portfolio allocations for each insurer in each year. The insurer asset and liability mutual fund return series for insurer k in year y were obtained as:

$$r_{Akyt} = \sum_{i=1}^{M} w_{kyi} r_{it} \quad \text{and} \quad s_{Lkyt} = \sum_{j=1}^{Q} x_{kyj} s_{jt} \tag{14}$$

where w_{kyi} is the proportion of insurer k's asset portfolio invested in asset category i in year y, x_{kyj} the proportion of insurer k's loss and premium reserves in insurance line j in year y, and M, Q are the number of asset and liability categories, respectively. These calculations yielded quarterly time series, r_{Akyt} and s_{Lkyt}, for insurer k in year y, where $t = 1,\ldots,60$ (a quarterly time series from 1975 through 1989). The standard deviations and correlation coefficient of these time series were used to calculate σ_{ky}^2, the overall portfolio risk parameter for insurer k in year y. The calculations were then repeated for the other years in the sample period using the insurer's portfolio weights appropriate for those years. [14] The result is an annual time series of σ_{ky}^2 for each insurer in the sample. The square roots of these volatility parameters are used in the regression estimation and are labelled as *SIGMA*.

This overall measure of portfolio risk represents a significant improvement over the traditional risk measures used in the financial literature on property-liability insurance. The typical approach to controlling for portfolio risk is to include asset and liability portfolio proportions as regressors. E.g., Harrington and Nelson (1986) use the proportion of assets in equities as a proxy for asset risk and the proportion of liabilities in various lines of insurance to proxy liability risk. Our portfolio risk measure incorporates more complete information about the composition of the asset and liability portfolio and accounts for correlations among assets and liabilities. Thus, it is more consistent with financial theory than prior approaches. It also reflects the major components of the NAIC risk-based capital formula, asset and underwriting risk, which together account for about 87 percent of total risk-based capital. [15]

3.2.2. Explanatory variables

Our principal hypothesis is that firms attempt to achieve target put values by choosing the levels of risk (σ) and capitalization (x). Thus, the level of *SIGMA* is

[14] Thus, the weights vary by year but the entire time series on r_{it} and s_{jt} are used in calculating the volatility and correlation parameters for a given year y.

[15] Our measure is superior to the NAIC's in its use of standard deviations, whereas the NAIC charges are based mostly on judgmental or worst-case criteria. However, the NAIC formula is more detailed than ours and allows the separation of loss reserve risk from the underwriting risk inherent in the current year's insurance coverage. The NAIC RBC formula could not be replicated for most of our sample period based on data available to us.

hypothesized to determine the target level of *CAP* (Eq. (9)) and the level of *CAP* is hypothesized to determine the target level of *SIGMA* (Eq. (10)). From Eq. (12) and (13), this implies that the risk parameter (*SIGMA*) appears as an endogenous explanatory variable in the capital-to-asset ratio equation and the capital-to-asset variable (*CAP*) appears in the portfolio risk equation. These variables should have positive coefficients if firms choose the levels of risk and capital to achieve solvency targets.

The natural log of total assets (*SIZE*) is included in both equations to control for differences in capitalization and risk by firm size. Larger firms are expected to be more diversified and thus to require less capital to attain a given solvency target. Thus, *SIZE* should be inversely related to the capital-to-asset ratio. *SIZE* is also included as a control variable in the risk equation because the method used to calculate sigma does not allow the loss ratio or asset volatilities to vary with firm size. Sigma is likely to be overestimated for large firms and underestimated for small firms, leading to a predicted positive coefficient for *SIZE* in the risk equation.

To test the hypothesis that the degree of separation of ownership and management affects risk-taking, we include two dummy variables: $CHMGT = 1$ if the firm is closely held by management and equal to 0 otherwise; and $CHOTH = 1$ if the firm is closely held by parties other than management, $= 0$ otherwise. The excluded category consists of publicly traded firms and firms owned by publicly traded parents. [16] If closely held firms adopt riskier strategies either because the interests of owners and managers are more closely aligned or because it is optimal for such firms to exercise more managerial discretion, these variables should have negative coefficients in the capital equation and positive coefficients in the risk equation. A somewhat weaker prediction is that the coefficients of *CHMGT* should be larger in absolute value that those of *CHOTH*.

Insurer organizational structures also differ with respect to the use of subsidiaries. About one-third of the insurers in our sample have no affiliates or subsidiaries. The remainder are insurance groups with several companies under common ownership and control. Two variables are included to account for the effects of group structure: a dummy variable (*SINGLE*) equal to 1 if the firm is an unaffiliated single company and 0 otherwise and the intra-group Herfindahl index based on net premiums written. Both variables are expected to be inversely related to capitalization and directly related to risk. Even though the companies comprising insurance groups are under common ownership, the individual group members are separate corporations. If a group member encounters financial difficulties, it could be allowed to fail without financial contribution from the other members of

[16] We were not able to reject the hypothesis that traded insurers had the same capitalization and risk characteristics as insurers owned by publicly traded parent organizations.

the group. [17] A group thus has the characteristics of a portfolio of options, worth more to owners and less to policyholders than if the same assets and liabilities were part of a single corporation. [18]

To test the regulatory costs hypothesis, we include a dummy variable equal to 1 if the firm is licensed in New York and equal to 0 otherwise. New York is widely recognized as the regulatory jurisdiction with the most rigorous licensing and solvency surveillance system. Thus, New York is more likely than other states to impose regulatory costs on firms in relatively weak financial condition. The regulatory costs hypothesis predicts a positive sign for this variable in the capital equation and a negative sign in the risk equation.

General economic conditions are likely to affect the adequacy of insurer capitalization, both because insurance profits are cyclical and because raising capital is likely to be easier when the economy is relatively strong. To proxy for business conditions, we use the rate of growth of industrial production. This variable is a coincident business cycle indicator (see U.S. Department of Commerce, *Survey of Current Business*) that is often used in analyses of securities markets (e.g., Bittlingmayer, 1992; Fama, 1990). Production growth is expected to be positively related to the capital-to-asset ratio. The yield on intermediate-term government bonds also is included in the capital equation because investment income and hence insurer retained earnings are directly related to interest rates. [19] These variables are not expected to affect *SIGMA* beyond their effects on capitalization and thus are not entered in the risk equation. The change in intra-year bond and stock volatility are entered in the risk equation to control for the effects of unanticipated shocks to the risk of the major asset categories that may temporarily move insurers away from desired portfolio risk levels. [20]

The equations also include a dummy variable equal to 1 for insurers operating nationally and equal to zero for regional firms. We expect a positive coefficient for

[17] In order for the creditors of an insolvent subsidiary to reach the assets of affiliates, claimants are required to 'pierce the corporate veil.' This is usually not possible as long as the affiliate or subsidiary was not formed in a deliberate attempt to defraud creditors. See Sargent (1989) for a discussion of the legal issues surrounding the 'corporate veil' concept.

[18] In most instances, reputational costs are likely to prevent the owners of a group from exercising their default option with respect to individual members of the group. However, as long as insurance markets react as though the probability of exercise is greater than zero, grouping is likely to be related to capitalization and risk.

[19] To the extent that interest rate expectations are reflected in the price of insurance, one would not expect retained earnings to rise with interest rates. However, to the extent that higher yields were unanticipated, retained earnings and hence capital will be higher.

[20] More specifically, the variables are the ratio of the current year's annualized monthly standard deviation of long-term government bond (Standard & Poor's 500 stock) total returns to the prior year's standard deviation for the respective series. These volatility changes are not fully reflected in the dependent variable (*SIGMA*), which is based on quarterly returns and differs from year to year primarily due to changes in the asset and liability weights. The results were qualitatively similar when the equation was estimated with these variables omitted.

this variable in the capital equation. More managerial discretion is required to operate nationally than to operate regionally because of the greater diversity of policies that must be underwritten and priced. More managerial discretion increases the policyholders' costs of monitoring the firm as well as the likelihood that owners will expropriate wealth from policyholders (Mayers and Smith, 1988). Thus, policyholders may demand higher capital in a national firm. The same agency theory argument applicable to the capital equation would predict an inverse relationship between the national firm variable and risk. A negative sign is also predicted if national firms are more diversified than regional firms.

Insurers distribute their products through two major distribution channels, independent agents, who represent several companies, and exclusive agents, who represent only one company. Our equations control for distribution systems by including a dummy variable (*AGENCY*) equal to 1 for independent agency firms and equal to zero otherwise. Regan (1996) argues that because independent agents have less insurer-specific human capital, insurers with independent agency marketing systems can take on higher levels of insolvency risk than exclusive agency firms. Thus, agency firms may tend to have lower capital ratios and higher portfolio risk levels than insurers with exclusive agents.

4. Sample selection, methodology, and results

4.1. Sample selection and methodology

Annual data for the period 1979 through 1990 from the A.M. Best Company data tapes were used to estimate the capitalization and risk equations. This is the longest period for which data were consistently available to us. Only firms with data available throughout the sample period were included in the sample. This minimizes the possibility of biases caused by start-up or insolvent firms, and parallels the approach taken in the banking literature (e.g., Marcus, 1983; Wall and Peterson, 1988). The sample is limited to stock insurers because the theoretical framework is most applicable to these firms. The sample includes all U.S.-owned stock insurance groups with data available for the entire sample period as well as all unaffiliated single firms which had net premiums written from all insurance lines of at least 0.0085 percent of total industry premiums in any of the years 1976, 1983, or 1990. [21] Two firms were eliminated based on an analysis of

[21] The premium criterion was chosen judgmentally to eliminate extremely small firms. The firms in the sample account for a high proportion of total stock insurance company revenues. For example, in 1990, the sample firms accounted for 83 percent of total stock company premium volume. Stock insurers wrote 68 percent of total industry premium volume in 1990, so the firms in our sample represented 56 percent of industry premium volume in that year. Percentages for other years are comparable.

Table 1
Summary statistics: 1979–1990

Variable	Mean	Standard deviation
Capital-to-asset ratio (*CAP*)	0.339	0.128
Portfolio standard deviaton (*SIGMA*)	0.132	0.044
ln(*ASSETS*)	19.095	2.029
Bond yield	0.101	0.021
National firm	0.197	na
Independent agency firm (*AGENCY*)	0.803	na
Closely held by management (*CHMGT*)	0.143	na
Closely held by others (*CHOTH*)	0.278	na
Unaffilited single company (*SINGLE*)	0.324	na
Intra-group Herfindahl index	0.428	0.372
Licensed in New York	0.613	na
Industrial production growth	0.019	0.043
Change in bond volatility	0.004	0.053
Change in stock volatility	0.001	0.090
Number of observations (142 firms for 12 years)	1704	

CAP is statutory capital plus GAAP adjustments divided by total assets (see text); *SIGMA* is estimated portfolio standard deviation (defined in text); bond yield is the intermediate-term U.S. government bond yield from Ibbotson Associates (1991); National Firm = 1 if firm operates nationally, 0 otherwise; Independent Agency Firm = 1 if firm uses independent agents, 0 otherwise; *CHMGT* = 1 if firm is closely held by management, 0 otherwise; *CHOTH* = 1 if firm is closely held by parties other than management, 0 otherwise; Single = 1 if firm is not part of a group, 0 otherwise; Intra-group Herfindahl index is based on net premiums written by the members of each insurance group (1 for Single companies); licensed in New York = 1 if New York licensed, 0 otherwise; industrial production growth is $\ln(P(t)/P(t-1))$, where $P(t)$ is industrial production index (U.S. Department of Commerce, Survey of Current Business); change in bond volatility is ratio of current to prior year's annualized monthly standard deviation of long-term government bond returns from Ibbotson Associates (1991); change in stock volatility is ratio of current to prior year's annualized monthly standard deviation of Standard and Poor's 500 Stock Index reported in Ibbotson Associates (1991). All data on insurance companies are from the A.M. Best Company property-liability insurance data tapes (Oldwick, NJ).

residuals from preliminary regressions. The final sample consists of 142 firms. [22] Summary statistics for the sample firms are presented in Table 1.

Two equations are estimated: a capital ratio equation and a portfolio risk equation. [23] Based on our experience with insurance data, autocorrelated errors were anticipated; and tests supported the hypothesis of autoregressive errors. [24] Because both equations have endogenous and lagged endogenous explanatory

[22] The search for outliers was based on Studentized residuals.

[23] In addition to the specification described here, an alternative specification was also estimated in which changes in capital and risk rather than levels were used as the endogenous variables. The results were essentially unchanged.

[24] Preliminary regressions confirmed the presence of autocorrelation for each of the equations. Because the equations include lagged dependent variables, Durbin's *h*-test was used.

Table 2
Dependent variable: capital-to-asset ratio

Independent variables	Coefficient (t-statistic)
Intercept	1.567 (3.843)
Capital-to-asset ratio (lagged 1)	0.096 (0.584)
Portfolio standard deviation	1.891 (2.567)
SIZE = ln(*ASSETS*)	−0.073 (−4.776)
Closely held by management (*CHMGT*)	−0.099 (−2.440)
Closely held by others (*CHOTH*)	−0.102 (−3.167)
National firm	0.068 (1.920)
Unaffiliated single company (*SINGLE*)	−0.127 (−3.074)
Intra-group Herfindahl index	−0.042 (−1.702)
Licensed in New York	0.019 (0.702)
Independent agency firm (*AGENCY*)	0.005 (0.135)
Industrial production growth	0.075 (3.197)
Bond yield	0.001 (1.624)
R-squared	0.449

Variables are defined in the footnote to Table 1.

variables, ordinary least-squares estimates would be inconsistent. To obtain consistent estimates, we use autoregressive two-stage least-squares (A2SLS) estimation, as described in Kmenta (1986, pp. 704–710). The procedure is designed to deal with the estimation of simultaneous equations with lagged endogenous variables and autocorrelation. Readers are referred to Kmenta (1986) for the details. The method involves transforming the data (using appropriate instruments for the lagged endogenous variables) to correct for autoregression and then using OLS. [25] In the OLS runs, the White (1980) test for heteroscedasticity led to rejection of the hypothesis that the error terms are homoscedastic. Thus, the t-statistics we report are based on White's heteroscedasticity-adjusted covariance matrix.

4.2. Estimation results

The estimated capital-to-asset ratio (capital) regression (Table 2) and risk regression (Table 3) provide support for the hypothesis that insurers choose capitalization and risk to attain solvency risk targets. The coefficient of the portfolio standard deviation in the capital equation is positive and statistically significant, implying that higher-risk firms hold more capital. [26] The coefficient of the capital-to-asset ratio in the portfolio risk equation is also positive and significant, i.e., better-capitalized firms take more risk.

Most of the other variables are also consistent with expectations. The two variables for ownership, representing firms closely held by management (*CHMGT*)

[25] The instruments are the current and lagged exogenous variables in the two equation system.

[26] Statements about statistical significance are based on a 5 percent level of confidence, based on a one-tail test, unless otherwise indicated.

Table 3
Dependent variable: portfolio standard deviation

Independent variables	Coefficient (t-statistic)
Intercept	−0.156 (−2.247)
Portfolio standard deviation (lagged 1)	0.296 (1.533)
Capital-to-asset ratio	0.135 (2.161)
SIZE = ln(*ASSETS*)	0.010 (3.073)
Closely held by management (*CHMGT*)	0.024 (3.017)
Closely held by others (*CHOTH*)	0.013 (2.756)
National firm	−0.011 (−2.755)
Unaffiliated single company (*SINGLE*)	0.031 (3.265)
Intra-group Herfindahl index	0.015 (2.616)
Licensed in New York	−0.004 (−1.124)
Independent agency firm (*AGENCY*)	−0.004 (−1.498)
Change in bond volatility	0.017 (2.208)
Change in stock volatility	0.010 (2.172)
R-squared	0.896

Variables are defined in the footnote to Table 1.

and those closely held by others (*CHOTH*) are negative and statistically significant in the capital equation and positive and significant in the risk equation. This is consistent with the hypothesis that the interests of managers and owners are more closely aligned in these firms so that these firms are more likely to adopt risky strategies. A complementary interpretation is that these firms have a comparative advantage in risky activities, because risky activities require more managerial discretion than safer ones. The coefficients of these variables are roughly equal in the capital equation, but in the risk equation the coefficient of *CHMGT* is nearly twice as large as the coefficient on *CHOTH*, as expected if owner–manager incentives are less closely aligned in closely held firms where owners do not participate in management.

The single insurer variable and intragroup Herfindahl index are both negative and significant in the capital ratio equation and positive and significant in the portfolio risk equation, consistent with expectations. The results with these variables suggest that insurance groups are viewed by the market as being more risky than unaffiliated single companies and that groups which concentrate their business in their lead companies rather than spreading it more evenly throughout the group are viewed as having relatively low risk. Such a result is consistent with the default option (corporate veil) hypothesis. [27]

The size variable (log of assets) is negative and significant in the capital

[27] There may, of course, be other possible explanations for these results. For example, unaffiliated single companies and groups with high Herfindahl indices may be relatively more successful in market segments and geographical areas where higher risk and lower capitalization is the natural market outcome. See Kim et al. (1992) for a related discussion.

equation, consistent with the hypothesis that large firms require less capital due to better diversification and/or better access to capital markets. This variable is positive and significant in the portfolio risk equation, as expected if our variable overestimates risk for large firms. The *NATIONAL* dummy variable is positive and significant in the capital ratio equation. It is negative and significant in the portfolio risk equation, as expected if national firms are more diversified and/or if policyholders require lower risk from these firms due to higher monitoring costs.

The dummy variable for New York regulation has a positive sign in the capital equation and a negative sign in the risk equation, as expected if regulatory stringency is associated with lower default risk. However, neither coefficient is statistically significant. Thus, we find only weak support for the regulatory costs hypothesis. This is perhaps not surprising given the criticisms of state regulation (U.S., House of Representatives, 1990; U.S., General Accounting Office, 1989, 1991) and the NAIC's recognition of the need for reform (Klein, 1995). This result is also consistent with the findings of Munch and Smallwood (1980), who concluded that insurance capital regulation had little impact on solvency beyond restricting entry of small firms into the market. As mentioned above, the adoption of risk-based capital was motivated by perceived inadequacies in solvency regulation, including low minimum capital requirements and regulatory forbearance.

The industrial production growth rate is positive and significant in the capital ratio equation, consistent with expectations; the bond yield is positive as expected in this equation but not significant at the 5 percent level of confidence. The change in bond volatility and change in stock volatility are positive and significant in the portfolio standard deviation equation. These variables control for the effects of exogenous factors on insurer capital and risk.

The distribution system variable (a dummy variable equal to 1 for independent agency firms) is positive and insignificant in the capital equation and negative and insignificant in the risk equation, contrary to the hypothesis that agency firms take more risk because independent agents can diversify their human capital risk across the firms they represent. A possible explanation for this result relates to the fact that agency firms are known to have higher costs and lower profit margins than direct writers (Cummins and VanDerhei, 1979). These firms may take less risk for a given solvency level to compensate for their lower expected retained earnings. [28]

[28] Several of the control variables measure overlapping influences, e.g., large firms are more likely to be licensed in New York, national firms are more likely to be large, etc. Accordingly, to check for the possible influence of multicollinearity on the results, we reran the equations alternatively eliminating variables we believed represented overlapping effects. The coefficients of the capital and risk variables had the expected signs and remained statistically significant in all of these runs, so the results with these variables are robust. The signs and significances of most of the other variables also were unchanged. The only noteworthy exception was that *NYREG* was statistically significant and negative in the *SIGMA* equation when the dummy variables for closely held firms were not present and also in the run when *SINGLE* and *IGHERF* were not present. Thus, it is possible that collinearity may be obscuring the effects of regulation on risk. However, another interpretation is that *NYREG* is proxying for the omitted variables in these test runs.

The partial adjustment model implies that the coefficients of the lagged endogenous variables in the capital and risk equations should fall between 0 and 1 (see Eq. (11) and (12)). One minus the coefficients of these variables are the estimated speeds of adjustment. The coefficient of the lagged value of the capital-to-asset ratio in the capital ratio equation is about 0.10, while the coefficient of the lagged value of the standard deviation in the portfolio risk equation is 0.30, implying speeds of adjustment of 0.90 and 0.70, respectively. However, neither variable is statistically significant at the 5 percent level (the coefficient of lagged *SIGMA* is significant at the 6.25 percent level). Thus, the evidence for the stock adjustment model is not very strong. This suggests that insurance markets are highly responsive to changes in safety levels.

5. Conclusions

This paper investigates the relationship between capital and risk in the property-liability insurance industry. We hypothesize a positive relationship between risk and capital in insurance markets, i.e., that insurers have target solvency levels that are achieved through the choice of capitalization and risk. Several non-mutually-exclusive hypotheses support this prediction. Hypotheses that carry over from the banking literature include the avoidance of regulatory and bankruptcy costs, managerial risk aversion, and protection of franchise values. Because the insolvency protection afforded by insurance guaranty funds is incomplete, we also advance the hypothesis that insurers have optimal capital structures because the demand for insurance is inversely related to default risk.

The implications of the model are tested using a pooled cross-section, time series sample of 142 property-liability insurers over the period 1979–1990. The results support the hypothesis of a positive relationship between capital and risk. This does not provide direct evidence that target solvency levels arise due to buyer demand for solvency. However, in combination with the results of other recent research showing an inverse relationship between price and risk in insurance markets (e.g., Cummins and Danzon, 1995), it does provide suggestive evidence consistent with this hypothesis.

We also provide evidence that managerial incentives play a role in determining capital and risk in insurance markets. The results show that closely held firms have lower capital and higher risk than publicly traded firms, consistent with the hypothesis that owner–manager incentives are more closely aligned in these firms than in widely-held firms. Our results do not support the hypothesis that regulatory costs played a significant role in determining insurer capital and risk levels during our sample period.

Our findings have significant implications for insurance solvency regulation. Because firms appear to have optimal capital structures and because most firms operate with capital ratios far above the regulatory minima, additional restrictions on risk-taking by well-capitalized firms may not be needed to achieve regulatory solvency goals, provided that regulators take prompt corrective action against firms in weak or deteriorating financial condition. Instead, regulators should focus their resources on monitoring solvency, improving the accuracy of the RBC formula, and taking appropriate action under the RBC system rules (Cummins et al., 1995).

6. For further reading

For further reading, see Davies and McManus (1991) and Gennotte and Pyle (1991).

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