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ABSTRACT

The choice of financial structure is appropriately viewed as a complex, multidimensional decision by insurer management. Specific attention is given to traditional theories regarding capital structure, including the tradeoff between the tax benefits and increasing probability of incurring the cost of financial distress associated with leverage, and the tradeoff between protecting franchise or charter value and expropriating value through increasing exposure to interest rate risk. Within this framework, the relation between leverage, interest rate sensitivity and firm value is investigated in the property-liability insurance industry. Equity value, as gauged by Tobin's q, is determined to be related to an insurer's choice of financial structure. It is shown that the market value of equity at first grows but then later declines as leverage increases. Interest rate risk has the opposite effect. Equity value first declines with interest rate risk, but then rises at high levels of interest rate risk. These results are consistent with the prediction that financial institutions will expend scarce resources to control risk in order to protect franchise value and may indeed be signaling the existence of these valuable intangibles via these actions.

Introduction

This article focuses on the joint role of capital structure and interest rate risk management as related elements in an insurer's overall financial strategy. Empirical evidence is presented that is consistent with the extended Modigliani-Miller propositions of an interior optimum leverage ratio. This situation is hypothesized to result from the combination of the tax shield associated with leverage and the costs associated with the increased probability of

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insolvency and financial distress. Evidence is also presented that a market reward is tied to the management of interest rate risk. Insurer equity value at first declines with increased interest rate risk, but then rises with high exposure to interest rate risk. This fluctuation is interpreted as a general market aversion to risk that is difficult for the individual investor to hedge (leading to the increased cost of financial distress without an offsetting tax shield) at low to medium levels of interest rate risk. However, high levels of interest rate risk are shown to reward those firms that operate in markets characterized by significant information asymmetries regarding the financial condition of individual firms. The decision to expend scarce resources in the control of interest rate risk is hypothesized to be related to the protection of the insurer's franchise value, and may indeed be used to signal the existence of this franchise value to outside investors.

The first section of this article develops the role of the insurer as a financial intermediary and notes the potential conflict between shareholder and policyholder. The role of equity capital (or "surplus") as a mechanism for controlling conflict is introduced and followed by a discussion concerning the option-like characteristics of the equity claim against the insurer's assets and the impact of interest rate risk on firm value. The second section reviews various theories regarding the impact of interest rate risk and financial leverage on the determination of optimal financial structure. Specific hypotheses, based on these theories, are presented for later testing. The third section presents a method for measuring the economic value and duration of assets and liabilities for a property-liability insurer. Q ratios (market-to-liquidation value) are estimated for a number of property-liability insurers. The sources of data used in the study, potential data limitations, and various measures of sensitivity to interest rate risk and leverage are discussed. The hypotheses are tested and results are presented in the fourth section, and a conclusion follows.

The Property-Liability Insurer as Financial Intermediary

Important insights are gained by viewing the insurer as a financial intermediary that issues contingent claims to a set of policyholders and uses the proceeds to purchase a portfolio of assets. Management is charged with investing the insurer's assets in order to maximize the risk-adjusted return on capital or, alternatively, maximize the value of ownership claims.[1] In offering insurance policies, the insurer effectively levers ownership capital by "borrowing" from the policyholders. A critical role of equity capital or "insurer surplus" is the creation of a buffer against the possibility that losses exceed the net premiums

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[1] Insurers are commonly organized as mutuals, reciprocals, and Lloyd's associations, as well as the stock form discussed above. The separation of claims against the assets of the insurer between owners, policyholders, and management is less clear in these other organizational forms, but the basic results of financial intermediation do not change. See Mayers and Smith (1988) and Staking and Aiuppa (1989) for a discussion of organizational form as a means of controlling the costs of agency conflicts within the property-liability insurance industry.

collected plus the interest and dividends earned between the time of premium receipt and the time of disbursement. The greater the capital, the more certain policyholders are that they will receive compensation for insured losses. Competition in insurance markets requires that premiums are set at levels that both compensate policyholders for the use of their funds and, in order to attract capital, also provide a competitive return to the shareholders as compensation for their role as residual risk bearers.

Several important differences between insurers and other financial intermediaries must be taken into account in analyzing the structure of the property-liability insurance industry. First, while in aggregate the claim against the insurer by the policyholders is similar to the claim of depositors or debtholders at other financial institutions, the claim of each individual policyholder is contingent upon experiencing a loss.

Second, insurance contracts are usually set up to cover losses incurred during a specified time period, while actual loss payments are made over a much longer time period. Policyholders are, in effect, purchasing a long-term financial commitment by the insurer. They cannot cancel past coverage and obtain refunds if they perceive that the riskiness of the insurer is increasing. Future business can be transferred to another insurer, but past exposures cannot be transferred without payment of additional premiums.[2] Since the insurer is able to change the risk levels once the insurance contract has been written, it allows for a unilateral transfer of risk to policyholders (and expropriation of value by shareholders). In the absence of a credible outside guarantee, this form of reverse moral hazard is priced in the insurance contract unless the shareholders can bind themselves to maintain risk levels. Thus, a second purpose of capital is to reduce the insurer's incentive to expropriate value from policyholders through unilateral decisions to increase risk.

In addition to laws governing the distribution of assets among the various claimants, the relation between the value of shareholder and policyholder claims against the assets of a property-liability insurer is based on the current value of insurer assets, time to maturity of the aggregate policyholder claim, and the stochastic processes underlying both asset returns and the aggregate policyholder claim. It is often convenient to view the relation between shareholder and policyholder in an option framework. In competitive markets with

[2] The sale of insurance following the recognition of loss is not common (see Smith and Witt, 1985; Venezian and Fields, 1987). One of the few, but well publicized, examples is the sale of insurance to MGM Grand Hotel following a major fire—in this case, there is clear evidence that the transaction was purely financial. Nevertheless, the problem at hand is purchasing coverage for past exposure (incurred but not reported) in the event that the financial condition of one's insurer has declined. Future exposure can be transferred by switching insurers, but any existing exposure is tied to the initial insurer. Particularly for longer tail lines, the policyholder enters into a long-term relationship with the insurer. The insured is limited in his or her ability to control for declines in insurer quality by canceling insurance as a depositor could withdraw deposits or sell his or her claim on a secondary market. Although insurance for past exposures exists, often via reinsurance-like contracts, they are not common due to the perception that major insurers, while they may go through financial difficulties, are expected to be able to pay off claims.

full information, policyholder premiums will reflect not only the current distribution of asset returns, but the ability to switch from one distribution to another. The option of shareholders to exercise their "put"—turning the assets of the insurer over to policyholders in satisfaction of policyholder claims—will be fully incorporated in premium levels. If management is able, without warning, to increase the variability of asset values once the policy is in place, shareholders will be able to extract value from policyholders.

Two of the most common methods of increasing risk and thereby extracting value from policyholders are increasing leverage and increasing exposure to interest rate risk. Premium levels will be forced lower by policyholders who recognize this risk. As mentioned above, by providing capital that will be relinquished if asset values decline, the insurer is able to bind itself not to expropriate value, and thereby it is able to command higher premium levels.

Financial Structure and Value: Capital Structure and Interest Rate Risk

Multiple Dimensions of Optimal Financial Structure

An extensive literature on optimal capital structure exists, and, although various schools of thought emphasize different elements, it is probably fair to say that a consensus is emerging.[3] The result of the capital structure literature, looking at taxes and either the costs of financial distress or agency costs and information signaling, supports the notion of an interior optimum where the value of the firm first increases with leverage, reaches a maximum at some optimal leverage level, and then declines as leverage is increased beyond this optimal level.[4]

Leverage is not, however, the only dimension of financial structure that is important. Liquidity, the structure of debt, sensitivity of assets and liabilities to changes in inflation and interest rates, the overall riskiness of the firm's investment portfolio, competition, and market reputation are all critical to the determination of optimal financial structure. Although leverage is likely the most important factor for many real-sector firms that borrow in order to finance specific investment projects, financial intermediaries must pay particular attention to some of the other factors. Since the investment portfolio of the

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[3] The *Journal of Economic Perspectives* published a summary and critical analysis of this literature (see, e.g., Miller, 1988).

[4] A problem arises trying to estimate the optimal capital structure for a group of firms. If all firms are operating at their optimum level and these optimums differ because of tax status, ownership of scarce resources, future investment opportunities, etc., we will end up finding a set of unrelated points. This problem exists for all empirical investigations of capital structure. In addition, the economic values of assets and liabilities change more rapidly than firms are fully able to adjust. Efficient financial markets that determine prices according to the consensus estimate of the current structure adjust much more rapidly than individual firms. Thus, the analysis based on a panel of similar firms across time will provide the best opportunity to test the theories. By selecting the very competitive property-liability insurance industry, where tax treatments are the same and virtually all inputs are available in competitive markets, this problem should be minimized. We are grateful to Greg Niehaus for directing our attention to this point.

typical, highly leveraged insurer is concentrated in long-term, fixed-income securities, interest rate risk is very important.

Surplus duration is used in this article to measure interest rate risk for an individual firm.[5] For insurers whose duration of assets is greater than that of their liabilities, rising interest rates typically will erode the value of surplus. This, in turn, leads to increased leverage, a greater probability of ruin, and an increase in the expected cost of financial distress. The decline in the value of surplus is greater for the firm that sustains a higher degree of leverage.[6]

The value of a property-liability insurer, like that of any other firm, depends on the chosen capital structure. However, unlike real-sector firms and most financial intermediaries, which can increase leverage by issuing debt instruments, insurers issue policies, promising to pay the unknown level of future losses to a cohort of policyholders. In effect, the insurer issues a stochastic debt instrument where neither the amount nor the timing of loss payments is known but must be estimated. The estimated loss payments are deductible from the insurer's pretax income, resulting in a tax effect similar to that of debt. We therefore expect that (in the absence of financial distress costs) the value of the shareholder's claim on the insurer will increase with leverage.[7] However, the insurer also faces the negative and potentially significant impact on shareholder value resulting from increases in agency conflict and in the expected present value of the cost of financial distress associated with increasing leverage. Since the insurer is selling its promise to make payments against

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[5] Three definitions of surplus are sometimes used. "Statutory surplus" is an accounting concept and is the sum of the contributed capital and retained earnings. It is also the difference between admitted assets and liabilities on the statutory balance sheet. "Economic surplus" is the difference between the market value of tangible assets and the present value of liabilities. This measure of surplus has a liquidation value focus. Finally, "market value of surplus" is given by the market value of the insurer's equity shares. This measure has a going concern focus, and includes the liquidation value as well as the franchise and put option values. See Babbel (1994) for further clarification. Our measure of surplus duration is based on the latter definition of market value of surplus.

[6] The effect of leverage on the duration of surplus can be calculated as follows. Let A = market value of assets, L = market value of liabilities, S = market value of surplus (= A-L), D_A = duration of assets, D_L = duration of liabilities, and D_S = duration of surplus. Since duration is a linear operator (i.e., the duration of a portfolio is equal to the weighted average duration of the individual securities),

$$D_S S = D_A A - D_L L,$$
$$D_S S = D_A A - D_L(A-S) = (D_A-D_L)A + D_L S,$$
$$D_S = (D_A-D_L)A/S + D_L.$$

Only those firms with surplus duration equal to zero are immune from the effect of interest rate changes. This is, of course, only a first-order approximation. Convexity mismatches and other higher-order effects of interest rate fluctuations on market values have been ignored (see Babbel and Stricker, 1987).

[7] Indeed, we may expect the tax effect to be stronger for property-liability insurers than for the typical firm, since the insurer has traditionally been able to deduct the nominal amount of expected losses from its taxes rather than the present value of such losses. This allowance was changed by the Tax Reform Act of 1986, which requires discounting of loss reserves (see Cummins, 1990).

losses in the future, the policyholder (and other agents representing the policyholder, including regulatory authorities) must be convinced that the insurer holds sufficient capital and that it will be able to honor fully its obligations.[8]

Interest Rate Risk and Financial Intermediation

Property-liability insurers, like other financial institutions, create value through the intermediation of risk—pooling risks associated with size, term, and credit worthiness—and repackaging these risks into securities that are attractive to the individual investor. These securities can be thought of as combinations of primitive Arrow-Debreu state contingent claims. Value arises when the payoffs spanned by these complex securities cannot be replicated by the individual due to economies of scale, transactions costs, information asymmetries, or, in the particular case of property-liability insurers, the highly-skewed probability distributions associated with rare events. Traditionally, it has been assumed that the intermediary is rewarded for providing these risk intermediation services. This "reward for risk bearing" concept has been interpreted by many financial intermediaries to entail a reward for assuming interest rate risk and is used to justify holding a mismatched portfolio, investing in long-term assets while liabilities are comparatively short-term. However, little empirical or theoretical support exists for this supposition.

Insurers that are not duration balanced undoubtedly will be subject to increased variability of returns and increased probability of ruin. The question is how this variability impacts firm value. Financial theory provides some insights by examining the incentives associated with differing financial structures. The alternative theories regarding the impact of leverage and interest rate risk on economic value are not necessarily contradictory. Rather, they address different factors that simultaneously affect firm value. The question is not the direction of each individual effect, but which effect is expected to dominate. The theories differ largely with respect to the ability of the firm's various claimholders to recognize financial risk and prevent expropriation of value by shareholders.[9]

Leverage and Duration Irrelevance

The argument can be made that, in perfect markets, a firm's choice of financial structure is totally irrelevant. This argument is presented first, not because it is considered more important than the other theories, but because it provides a basis for examining them. The assumption of perfect markets is unrealistic, but the resulting model is useful for pedagogical purposes. Like the Modigliani-Miller capital structure model, the result is not as important as

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[8] Cummins and Lamm-Tennant (1994) provide evidence of a positive relationship between both insurance and financial leverage and property-liability insurers' cost of capital.

[9] In the case of property-liability insurers, current and potential policyholders constitute an important set of claimants to which particular attention must be given. The degree to which policyholders (or regulators as representing policyholders) are able to evaluate and monitor insurers' activities is unclear, leading to some interesting applications of agency theory.

what the result indicates about the underlying assumptions. Given the standard assumptions of complete and frictionless security markets (including perfect information, no taxes or transactions costs, and efficient markets for all elementary securities), arbitrage arguments establish that hedging behavior, if costless, has no effect on firm value. Both shareholders and policyholders will be indifferent regarding the degree to which risk is hedged. If costly, hedging behavior will reduce the value of the firm since scarce resources are being expended to eliminate individual or nonsystematic risk that already has been diversified by the individual shareholders. Security-specific risk is eliminated through diversification. Because markets are complete, policyholders likewise can obtain any desired risk profile through portfolio formation (see Smith and Stulz, 1985).

It should be obvious that insurers (and other financial intermediaries) would not exist under such conditions. However, like the original Modigliani-Miller irrelevance arguments, insights into the value of asset-liability management can be gained by turning around the arguments. Firms spend considerable resources in asset allocation decisions. If the selection of a particular level of interest rate risk matters, it is because one or more of the aforementioned assumptions is violated.

Value of Increasing Risk: The Option to Default

Several studies have indicated that the existence of state guarantee funds, which do not charge risk-adjusted premiums, provides an incentive for the insurer to increase volatility.[10] Hedging behavior (even if costless) will not be undertaken, because it results in reduced volatility and lower shareholder value. The guarantee fund, in effect, provides the insurer with an additional off balance sheet asset: the right to "put" the policies to the guarantee fund if the value of the assets is insufficient to cover the liabilities. An alternative way of thinking about the value of this put option is as the difference between the cost of debt (i.e., insurance policies) without the guarantee and the cost of debt with the guarantee. Decreasing the volatility of surplus through hedging will decrease the value of the put without changing the value of the liabilities, thereby reducing the market value of surplus.

If the increased variability is fully reflected in reduced insurance premiums, there would be no impact on insurer value.[11] However, if such variability is not priced in insurance contracts, share values will increase with increased (absolute) surplus duration. There are two situations where this would be the case: when the policyholder has biased information regarding the riskiness of the insurer or is unable to assess this risk and when the policyholder is covered by a credible outside guarantee and is therefore indifferent with regard to the risk

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[10] See Cummins (1988) for a more detailed development of the impact of guarantee funds on policyholder behavior and insurer risk taking.

[11] The policyholder, in effect, lowers the price he or she pays for the insurance protection due to the increased risk of the insurer. The value of the put option is therefore reduced.

of the primary insurer. In the presence of a credible outside guarantee, it is likely that the consumer will have little incentive to evaluate the financial stability of any particular insurer. The cost for the consumer to obtain the information necessary to evaluate risk is often too high compared with the value of the information. Instead, many consumers rely on reputation or recommendations by friends, associates, and agents for selection of an insurer and rely on the competence of government regulators or guarantee funds for protection.[12] Moreover, even for large corporations that employ professional risk managers and conduct due diligence in the selection of a risk carrier, the ability to evaluate insurer solvency is far from perfect. Given this lack of information, the unilateral actions designed to increase risk and thereby expropriate value from policyholders are be exploited by some insurers. Adding to this risk is the fact that regulatory practices tend to ignore economic values, and many state insurance departments are neither staffed nor trained to evaluate financial risk.

The existence of guarantee funds that charge non–risk-based premiums can increase the value of the option to default even when consumers are knowledgeable. If policyholders, particularly those who are fully covered under the limits of the state guarantee funds, are insensitive to the probability of default, the insurer can increase risk and expropriate value from the guarantee fund. This is particularly problematic when guarantee funds do not actually exist, but are paid through post-loss assessments. Firms that impose the greatest risk on the guarantee funds and become insolvent avoid paying any charges associated with the guarantee fund.

Agency Costs and the Value of Hedging Behavior

The literal interpretation of the value of the "option to default" presented in the previous section is limited, because it does not take into account some important aspects of the insurer's relation to its full set of stakeholders. When the full set is considered, hedging (even if costly) can result in increased value for the shareholder. Value is created when the cost of hedging is lower than the offsetting reduction in expected insolvency costs.

Several reasons lead us to believe that policyholders will demand a higher degree of solvency than shareholders with limited liability would choose in the absence of policyholder constraints. First, policyholders, whether individuals who insure because of risk aversion, or large widely-held corporations who

[12] All states protect policyholders from insurer default up to a level of $350,000 per claim by requiring insurers to participate in a state-operated guarantee fund program (Klein, 1995). The existence of guarantees may reduce the degree of care exercised by insurance purchasers and their agents, potentially limiting the extent of market controls over individual insurers. The degree of market discipline that exists most likely results from the risk managers and brokers of large corporations and/or the ratings of the claims-paying ability provided by Moody's and Standard and Poor's. Whether the existence of these funds has encouraged the insurance industry to seek better solvency regulation (or self-regulations)—providing some degree of market discipline—has not been fully explored.

choose to insure for other reasons, view the insurance policy as a long-term commitment.[13] Unlike shareholders who can sell their ownership claim, policyholders have very limited options if they are not satisfied with the actions taken by the insurer once the policy has been written.

Second, policyholders will avoid relationships with insurers who are perceived as likely to change risk levels once a policy has been written. An important way of signaling a long-term commitment not to change the level of risk is by increasing the level of capitalization.

Third, the insurer does not operate with a closed book of business. Maximizing the value of the firm on a going concern basis requires the insurer to continue writing and renewing profitable business. This being the case, the insurer would be unable to change the level of risk for existing policyholders without jeopardizing its ability to market new policies. Some business, for example, cannot be underwritten unless the insurer obtains a minimum grade from one of the rating agencies. If such business is valuable, hedging will be undertaken if necessary to obtain the required rating.

Fourth, the coverage of state guarantee funds is limited. With the exception of New York, the "funds" are unfunded, and there are limits to assessments that can be levied in any year. The failure of a large (or several small) insurers could result in delays in the receipt of funds by the injured parties for a number of years. The typical limit of $350,000 is far too low for many commercial risks. Moreover, some commercial risks are excluded altogether by guarantee programs.

Fifth, if the cost of financial distress is high, an insurer will chose to take steps to hedge risk even when hedging is costly. The franchise value of an insurer (name, reputation, agency force in place, licensing agreements with the various states, etc.) is an important source of value that is lost in the event of insolvency. It is not unrealistic to assume that an insurer which is perceived to be imposing risk on policyholders will find it difficult to maintain or increase premium volume. An important portion of the present value of future insurance operations is due to relations with agents, brokers, and rating agencies—each of whom has undertaken a major investment in developing a reputation for providing information (including solvency information) to policyholders. Since independent agents and brokers are able to switch business to competing firms in order to maintain and protect their own investment in reputation, shareholders of firms using these distribution systems are prevented from taking advantage of opportunities to capture value at the expense of existing policyholders. Because the franchise is valuable, and this value may be lost in the event of insolvency or financial distress, the insurer will expend resources to protect it. Moreover, since the franchise value is not readily observed, the insurer's ac-

[13] Diversified corporations may purchase insurance for a number of reasons, including efficiency in claims administration, expertise in risk measurement and control, and/or the tax advantages of insurance, as well as risk trading among claimholders and financial management purposes. See Mayers and Smith (1985), Main (1983), Staking and Bernier (1989), and Chen and PonArul (1989) for discussions of the corporate demand for insurance.

tions to protect it, including the control of leverage and interest rate risk, provide an important signal regarding this value to outsiders.

Two models from the banking literature that examine the control of risk-taking activities by commercial banks are relevant to the situation of risk taking by property-liability insurers. Marcus (1984) attempts to explain the existence of a bimodal risk classification within the banking industry. He develops an option model in which the value-maximizing bank chooses either a high-risk or a low-risk strategy while mid-range options are suboptimal. Banks with high franchise value will maximize wealth by reducing the variance of asset values, while marginally solvent or truly insolvent banks that have not been so declared by the regulatory authority will maximize value by increasing portfolio variance. Marcus concentrates on increasing credit risk, but his model is equally appropriate to changes in financial risk associated with increasing leverage or increasing interest rate exposure.

Herring and Vankudre (1987) present a similar model in which franchise value is based on growth opportunities. An interesting result is that riskiness depends not only on the value of the growth opportunities, but also on their liquidity. If a firm can borrow against growth opportunities, its incentive to increase risk is reduced. Nevertheless, much of the franchise value is based on superior information regarding growth opportunities that are difficult to convey to security markets without revealing the information and, in the process, destroying its value.

McDonald (1993) demonstrated that the probability of default is bimodal in the property-liability insurance industry. The majority of firms are seemingly well capitalized while a small number of firms are close to insolvency. Very few firms are located in the middle.[14] The models of Marcus and Herring and Vankudre, which predict such a bimodal risk distribution, are therefore very applicable.

Interest Rate Risk and Regulation

The property-liability insurance industry in the United States is subject to a considerable degree of regulation, much of which is centered on maintaining the solvency of individual insurers and the integrity of the insurance industry. Because regulation has a significant influence on the operations and practices of the insurance industry, this section briefly outlines the impact of regulation on financial structure.

The solvency regulation of property-liability insurers is uniquely different from that of other financial institutions. Rather than focus on asset risk, the focal point has traditionally been on liability risk. Insurers generally concentrate their portfolios in long-term, high-quality, fixed coupon bonds. Because

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[14] McDonald (1993) developed a solvency prediction model based on the generalized beta II (GBII) family of probability distributions. In addition to superior reliability vis-à-vis logit, probit, and multiple discriminate analysis, the GBII analysis provides additional flexibility by not imposing symmetry on the underlying distributions.

the default risk of these bonds is low, if bonds are held to maturity, the face value will eventually be received. Regulators, working under the assumptions that bonds are held to maturity and that loss reserves are stated in nominal dollars, have allowed insurers to carry bonds at amortized book value. The resulting distortion in both economic values and incentives for insurers to control interest rate risk are potentially serious.

Upon examining the pervasiveness of interest rate risk within the property-liability insurance industry, it is surprising that until recently a regulatory framework designed to measure and/or control this source of risk did not exist.[15] The Insurance Regulatory Information System organized by the National Association of Insurance Commissioners to detect problems among property-liability insurers completely ignores interest rate risk. Even risk-based capital standards measure the interest rate risk of only one side of the balance sheet. The use of derivative financial instruments (such as options and futures), which are often best suited for hedging interest rate risk, is severely limited. In fact, the statutory accounting system imposed on the property-liability insurance industry actually encourages increased interest rate risk in a number of ways.

One reason that insurers invest so heavily in long-term bonds is that they are able to capture income from the high yields generally associated with longer-term bonds (allowing statutory capital to increase more rapidly in the early years) without having to bear the risk. Although this accounting treatment might lead to greater stability in accounting measures of asset and surplus, it does not reflect true economic values.

The statutory accounting system also enables property-liability insurers to engage in income smoothing. Income can be increased or decreased almost at will by selling assets that are priced above or below book values in order to meet regulatory solvency standards or for tax management purposes.[16] Since the declaration of insolvency is based on statutory rather than economic condition, a firm can delay formal declaration of insolvency for a number of years. The cost of allowing an economically insolvent insurer to operate for long time periods can be enormous in terms of policyholder losses, guarantee fund commitments, and adverse incentives to increase risk.

Tobin's Q Ratio as a Measure of Market Reward for Financial Structure

Tobin (1969) introduced q, the ratio of market value to replacement cost as a measure of the propensity for increased capital formation in the economy as a whole. When q is less than one, there is no aggregate incentive to invest and firms will consume existing capital. Conversely, when q is greater than one, firms have an incentive to invest. Eventually, as investment opportunities car-

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[15] The lack of regulatory emphasis on interest rate risk in the past was probably derived from the fact that much of the regulatory structure evolved during periods of relatively low interest rate volatility.

[16] See Cummins and Grace (1994) for evidence that insurers use capital gain and loss realization to manage taxable income.

rying positive economic rents are exploited, aggregate q will decline to the long-term equilibrium value of unity.

Lindenberg and Ross (1981) extend Tobin's macroeconomic analysis to examine the value of q for individual firms in an industrial organizational framework. They assume that, in an open market economy when the individual firm has q greater than one, competition will be attracted to the specific industry until the economic rents associated with the higher q are eliminated.[17] Only firms with some degree of monopolistic power would be able to maintain q ratios in excess of unity. They proposed q as a proxy for monopolistic power and after extensive testing concluded that q was superior to the traditional measures of concentration as a measure of monopolistic power.

Smirlock, Gilligan, and Marshall (1984) reexamine the use of q as a measure of monopoly power and economic rents. They argue that the market valuation of the future economic returns for a firm is "appropriately capitalized by an efficient capital market," in contrast to the usual measures of profitability, which include distortions imposed by accounting rules and tax laws. However, rather than simply imputing monopolistic power to the firm with q greater than one, they divide total firm value into three components: the present value of the existing capital stock, capitalized rents associated with monopolistic power, and capitalized rents associated with ownership of scarce resources. In their analysis, q provides an upper bound for monopolistic power.

An alternative explanation of the q ratio is given by Smith and Watts (1992), who use an industry-based q ratio as a proxy for the existence of growth opportunities. They show evidence of an inverse relationship between q and leverage; that is, firms with higher growth opportunities will tend to be less leveraged. Maintaining higher levels of capital can be interpreted as a signal that the firm has growth opportunities and provides a clear indication that the firm is committed to them (helping to mitigate the problem with underinvestment). Firms in industries with higher growth opportunities may also not want to share the potential gains with bondholders. Likewise, Nance, Smith, and Smithson (1993) relate the use of hedging to firms that have more growth opportunities. Again, this may be taken as a signal that management does not want to place the growth opportunities at risk.

For a financial intermediary where firm concentration ratios are fairly low, exit and entry are relatively unrestricted, and the majority of investments are publicly traded financial assets, q takes on a slightly different interpretation. Even when monopolistic power is not present, economic rents associated with the ownership of scare resources exist. In particular, the value of reputation, existing distribution networks and renewal rights on existing business, arrangements with reinsurers, the value of information regarding specific risks, and other similar factors that permit the firm to undertake profitable future busi-

[17] This discussion is only appropriate if the focus is on "marginal q." With inframarginal activities, rents will be capitalized into market values and "average q" could be quite large, yet not imply any gains from entry in a competitive market.

ness—often referred to as the value of goodwill or franchise value—will be capitalized in market prices. Part, if not all, of this franchise value will be lost in the event of insolvency or even in the event of a substantial increase in financial distress. It is therefore in the firm's interest to protect its franchise value by eliminating some risks that would otherwise be undertaken.

Keeley (1988), in an analysis of commercial banking, demonstrates a clear relation between decreased franchise value and increased risk. In his analysis, increased competition and decreased barriers to entry associated with changes in interstate banking restrictions, geographical restrictions on the granting of new charters, expanded powers of savings and loan associations, etc. reduce the value of bank charters. Banks responded by increasing asset risk and reducing capitalization, effectively increasing the value of the option to default. Keeley argues that, prior to deregulation, the existence of a positive franchise value prevented the predicted increase in risk-taking behavior associated with guarantee funds. His arguments are equally applicable to the insurance industry. Property-liability insurers face increased competition from commercial banks, risk retention groups, and other nontraditional insurance mechanisms, as well as a growing militancy among consumer groups. All of these factors operate to reduce the value of the insurer's charter.

This article looks at the q ratio as a measure of franchise value. Whether this stems from growth opportunities or from the existence of some other set of assets that contain firm-specific values that insiders wish to protect, the firm may signal to other potential investors the value of these assets by committing resources to protect them. The approach used in this analysis has several advantages over existing studies. First, we concentrate on a particular industry (property-liability insurance), which minimizes the problems noted by Smith and Watts (1992) and others regarding differences across industries and particularly mixing financial and nonfinancial firms or regulatory environments. Second, by moving beyond the simple, linear relations between leverage, hedging activities, and firm value, we capture the more comprehensive, nonlinear relations that are predicted by a combination of the standard tax/financial distress/growth opportunities/leverage models with the predictions of financial theories vis-à-vis the value (and potential distress) resulting from increasing volatility. Finally, since the property-liability insurance industry is fairly mature and financial in nature, operating with high levels of leverage and interest rate risk, and at a time of considerable distress to the industry, we are able to work with a potentially rich sample of firms with varied approaches to the leverage/hedging tradeoff.

Methodology

To estimate the market reward for controlling interest rate risk, we use an adaptation of Tobin's q, the ratio of market-to-liquidation value of surplus. Formally,

$$q = q(D, L, S), \tag{1}$$

where q = ratio of market-to-liquidation value,
D = duration of surplus,
L = leverage (assets/capital), and
S = other structural factors.

Because market prices are needed to construct q ratios, the study is limited to stock insurers whose shares are actively traded. We use year-end data from 1981 through 1987 for 25 publicly traded property-liability insurers.[18] Market value of surplus is measured using the year-end stock price multiplied by the number of shares outstanding. Liquidation value of surplus (i.e., "economic surplus"—see footnote 5) is obtained by calculating the difference between the estimated economic values of tangible assets and liabilities. Because a majority of the assets of the typical property-liability insurer are traded on financial markets, and the liabilities represent a stream of future cash flows associated with business already written, an economic valuation can be undertaken. To obtain the market value of tangible assets we rely on the Schedule 10K reports filed with the Securities Exchange Commission, where publicly traded insurers are required to declare the market value of their stock and bond portfolios. We make an additional adjustment for property-liability insurers with life subsidiaries: Since the interest rate risk and financial leverage of property-liability and life insurance operations are very different, the assets and liabilities of the life insurance operations were stripped from the consolidated statements and treated as an investment in a life insurer.[19]

An economic valuation of the liabilities is more difficult. It is not possible to obtain market prices for loss reserves. Insurance reserves are not traded on organized markets, and most reinsurance arrangements are transaction-specific and are not publicly reported. It is, however, possible to approximate the economic value of the loss reserves based on expected future loss payments. A technique has been developed to model the historical payment patterns (and project the future cash payments associated with the existing book of business). The general approach—aggregate claims reserving—makes use of maximum likelihood estimates of future cash flows based on the structure of past loss payments. This method is selected because it does not require extensive information regarding individual losses (or, alternatively, the functional forms

[18] Not only share prices but also a continuous series of actual loss payments and market valuations of investment portfolios are needed over the entire span of the study. We found only 25 insurers that meet all of the data needs of our study.

[19] Stripping the life insurer operations could result in increased measurement problems if cross guarantees existed between property-liability and life subsidiaries. Fortunately, explicit cross guarantees between life and property-liability insurers generally are not found and are in some states prohibited. Although implicit cross guarantees may exist, the life insurer holdings are generally small (typically less than 5 percent of the assets of firms in the sample; most had no life holdings whatsoever). Given the data limitations on the financial structure of the life subsidiaries, the stripping procedure is a reasonable approximation. Even greater levels of measurement error and potential distortions would have resulted had we not attempted to eliminate the impact of the life insurance subsidiaries.

of the underlying loss distributions) and allows a separation of inflation (loss escalation) from the timing of loss payments (loss tail) while simultaneously controlling for insurance volume. Projected future payments are then discounted by the current interest rate term structure to obtain a present value of the loss reserves.

Much of the pioneering development of the aggregate loss methodology is due to Taylor, and the method used in this analysis is a modification of one of Taylor's models.[20] A detailed description of Taylor's separation method and the modification used in this article is presented in the Appendix. Because the factors are calculated using real (inflation-adjusted) historical loss payments, the projected loss payments fluctuate with changes in the term structure and underlying inflation rates. This function allows a dynamic approximation of the economic value of loss reserves. The separation method is utilized to estimate future losses and the present value of the loss reserve for "long tail" lines.[21] Losses on the "short tail" lines are easier to predict (and less subject to managerial discretion). Economic values of short tail lines are estimated by discounting the projected losses with interest rates that reflect average maturity.

Use of Linear Regression Analysis

A nonlinear estimate of the model presented in equation (1) is tested using regression analysis. Because of the potentially serious measurement problem associated with estimates of the liquidation values, the regressions are based on a modification of an inverted q ratio.[22] A few observations in the later years of the sample show a slightly negative estimated liquidation value (i.e., the firms are considered insolvent on a liquidation value basis). Because the negative values may be associated with measurement error, taking the reciprocal of

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[20] Taylor's primary concern is with enabling the actuary to estimate the total reserve by separating past losses into a tail component and a loss escalation component on the basis of nominal losses paid against a single claim or loss exposure unit and then multiplying claims by the total number of claims (which is assumed to be known). Our modification to this original method separates the entire portfolio of losses into three components: loss tail, loss escalation, and premium growth. Because our analysis is based on inflation-adjusted historical loss payments, and valuations are based on current inflation and term structure, the modifications should be superior to Taylor's method for the purpose of asset-liability management. For a detailed analysis of a number of loss reserve methodologies, refer to Taylor (1986).

[21] Schedule P (long tail lines) includes auto liability, multiple peril, general liability, medical malpractice, and workers' compensation. In 1987, Schedule P lines accounted for 69.5 percent of total premiums and 72.3 percent of total stated loss reserves for the property-liability industry as a whole.

[22] Measurement error in the denominator of a ratio that is expected to vary around unity will result in significant and nonsymmetric volatility. Positive measurement error will result in the q ratio being slowly compressed toward zero, and negative measurement error will result in the ratio rapidly being inflated toward infinity. If the negative error is large, small changes may cause discontinuities with the ratio fluctuating from a very large positive to a very large negative number. By moving the measurement error from the denominator to the numerator, the volatility is lessened. The authors are indebted to Marshall Blume, who pointed out this methodology for reducing variance.

these small negative numbers defeats the purpose of inverting the q ratio. Therefore, a constant of two is added to q prior to taking the reciprocal to minimize the potentially severe nonlinearities. This ratio QINV2 = 1/(q+2) is the dependent variable in the regressions.

Leverage and surplus duration can be estimated based on the structure of assets and liabilities using year-end values. Because there is some evidence that the impact of surplus duration, leverage, and the q ratios have been changing over time, two models are used to evaluate the market reward for jointly controlling leverage and interest rate risk. The first model combines all of the data, assuming that they are independent observations, into a single regression. The general model can be written as

$$QINV2_{it} = \alpha + \beta_1 L_{it} + \beta_2 D_{it} + \beta_3 L^2_{it} + \beta_4 D^2_{it} + \varepsilon_{it}, \tag{2}$$

where $QINV2_{it}$ = the inverse Tobin's q ratio of observation i at time t,
L_{it} = leverage of observation i at time t,
D_{it} = surplus duration of observation i at time t, and
ε_{it} = random error associated with observation i at time t.

The form of this equation is very generalized. Depending on the sign and significance of the estimates, the equation can represent a plane, a knoll, or a saddle shape in three-dimensional space. This equational form was specifically selected to capture the nonlinearities predicted by theory. Just as variants of the Modigliani-Miller theory predict nonlinearities with value first increasing with leverage and then dropping as the probability of incurring some costs of financial distress increases, the alternative theories presented earlier predict a variety of linear and nonlinear changes in value resulting from the firm's decision to increase volatility by taking on exposure to interest rate risk. Although several functional forms may be used to model the nonlinearities, we found the squared terms for leverage and duration to capture the essential nonlinear shape and to be statistically significant.

In addition, to control for some time-dependent changes in the q ratios (due to underwriting cycles, changes in regulation, etc.), we employ separate regressions for each year, constrained to have the same parameters for all the betas (i.e., only the intercept was allowed to change).[23]

$$QINV2_{it} = \alpha_t + \beta_1 L_{it} + \beta_2 D_{it} + \beta_3 L^2_{it} + \beta_4 D^2_{it} + \varepsilon_{it}, \tag{2a}$$

The results of this analysis are consistent in sign with the analysis of the entire data panel, while the results are statistically stronger. Both sets of results are presented below.

[23] This technique is similar to using a dummy variable for each year (other than the base year), but the constrained regression on SAS™ is able, in a panel framework, to take advantage of the existence of separate variance-covariance matrices for more efficient use of the available data.

Measurement of Duration

Duration can be thought of as the value-weighted maturity of cash flows with respect to a particular investment asset, or as a measure of the sensitivity of the price of an asset to interest rate changes. Year-by-year analytic measures of duration are calculated for each insurer in the sample based on the structure of assets and liabilities.[24] Simple Macaulay duration measures are adequate for our purposes, given the limitations of our data set. Surplus duration can be directly calculated from the duration of assets, duration of liabilities, and leverage. Thus,

$$D_S = (D_A - D_L)(A/S) + D_L, \qquad (3)$$

where D_S = duration of surplus,
D_A = duration of assets,
D_L = duration of liabilities,
A = market value of assets, and
S = market value of surplus.

In the calculation of leverage, generally accepted accounting principles assets adjusted for the market value of the bond portfolio, the estimated level of intangible assets or goodwill, and the estimated value of life insurance operations are divided by the market value of surplus. The calculation of the duration of assets and liabilities is based on the detailed regulatory filings. Equities are assigned the duration of the Standard and Poor's 500 portfolio, and the duration of the bond portfolio is based on the average life. These calculations are then adjusted to account for differences in the relative volatilities of government, corporate, and municipal bond yields.

Results

This section presents the results of our investigation of a market reward (as measured by Tobin's q, the ratio of market-to-liquidation value) for the management of leverage and interest rate risk. The evidence indicates that management of financial structure is associated with perceptions of market value. Nevertheless, the statistical results must be analyzed with care, partially due to the small sample size necessitated by data limitations and to the difficulties in approximating liquidation values. Moreover, the measurement error problem is potentially severe for some items.[25] The results must therefore be taken as indicative and not conclusive. In addition, financial management—controlling

[24] In addition to the analytic measure of duration used above, empirical measures of duration were calculated by regressing stock returns on interest rates. Results similar to those using analytic duration were found, although the statistical significance was weaker. Considerable evidence indicates that surplus duration varies considerably from year to year due to changing economic conditions and financial structure. Because of the instability, we lack sufficient data points to determine an accurate year-by-year empirical duration estimate using monthly data.

[25] See Staking (1989) for a detailed discussion of the measurement error problem.

leverage and interest rate risk—is only one element affecting firm value. Other aspects, such as the insurer's underwriting strategy, distribution systems, reputation, and overall managerial quality, are extremely important.

Table 1 presents the descriptive statistics for the variables used in the regressions. Considerable variation exists among the firms included in our sample. Leverage (after adjusting for the market value of equity and the present value of loss reserves) ranges from 1.4 to 15.4, with a mean of 3.5. Even greater variation is found in measured equity duration, with response to a 1 percent change in interest rate ranging from 2.4 to 49.3 percent, and a mean of 9.7 percent. Likewise, the ratio of market value to measured liquidation value ranges from -1.3 (indicating technical insolvency) to 15.1, with a mean of 1.47. These broad ranges contribute to the robustness of the regression analysis.

Table 1
Descriptive Statistics: 1981–1987

Variable	*N*	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
Q	175	1.47	1.63	-1.31	15.05
QINV2	175	0.32	0.11	0.06	1.45
L	175	3.47	1.77	1.40	15.41
LL	175	15.16	21.53	1.97	237.45
D	175	9.68	5.75	2.37	49.28
DD	175	126.56	212.99	5.64	2,428.82

Table 2 presents the results of the regression analysis. The left side of Table 2 presents an analysis using an ordinary least squares procedure using the entire panel of data in a single equation; the right side presents the analysis where the regression is run separately for each year, but the parameters (with the exception of the intercept) are constrained to be equal. In interpreting the results, we note that the dependent variable is the inverse q ratio. The signs on the parameters therefore must be reversed in order to properly interpret the effect on q. Both equations show that approximately one-third of the observed variation can be attributed to the leverage and duration variables (and their squares)—indicating that two-thirds of the variation can be attributed to other, unknown firm-specific variables. The minor variations of the yearly intercepts in the constrained equation indicate that some variation can be attributed to the calendar year (e.g., specific impact of major losses, changes in the underwriting cycle, etc.), but the data are not sufficiently rich to draw any conclusions. Because of the similarity of the results, the following discussion concentrates on the ordinary least squares estimates on the left side of Table 2.

The regression equations demonstrate a relation between the market's perception of the existence of franchise value (as measured by the inverse q ratio) and a firm's choice of financial structure. The statistical significance of the variables combined with a reversal in sign on both squared variables indicates a dependency between the franchise value and leverage, duration, and their squares that maps a nonlinear saddle shape. In particular, an increase in fran-

Table 2
Market Reward for Financial Structure
Using an Adjusted Inverse Q Ratio

Ordinary Least Squares Estimate

Source	*Sum of Squares*	*Mean Square*	*F-Value*	*Pr > F*
Model	0.770	0.1925	21.742	0.0001
Error	1.506	0.0089		
Total	2.276			

R^2 0.338
Adjusted R^2 0.323

Variable	Estimate	t-Statistic	Probability	Standardized Estimate
Intercept	0.35308	12.713	0.0001	0
L	-0.11780	-6.207	0.0001	-0.1018
D	0.03039	6.338	0.0001	0.1591
LL	0.01644	7.659	0.0001	0.4668
DD	-0.00134	-7.049	0.0001	-0.1381

	F-value	Probability
Leverage Test	36.04	0.0001
Duration Test	25.03	0.001

Constrained Ordinary Least Squares Estimate

Source	*Sum of Squares*	*Mean Square*	*F-Value*	*Pr > F*
Model	0.813	0.0813	9.126	0.0001
Error	1.461	0.0089		
Total	2.276			

R^2 0.357
Adjusted R^2 0.318

Variable	Estimate	t-Statistic	Probability
Int81	0.35339	14.29	0.0001
Int82	0.34218	12.87	0.0001
Int83	0.32962	12.91	0.0001
Int84	0.35239	8.47	0.0001
Int85	0.33545	13.30	0.0001
Int86	0.37894	16.14	0.0001
Int87	0.35936	13.18	0.0001
L	-0.12372	-7.49	0.0001
D	0.02392	7.35	0.0001
LL	0.01695	9.20	0.0001
DD	-0.00076	-8.38	0.0001

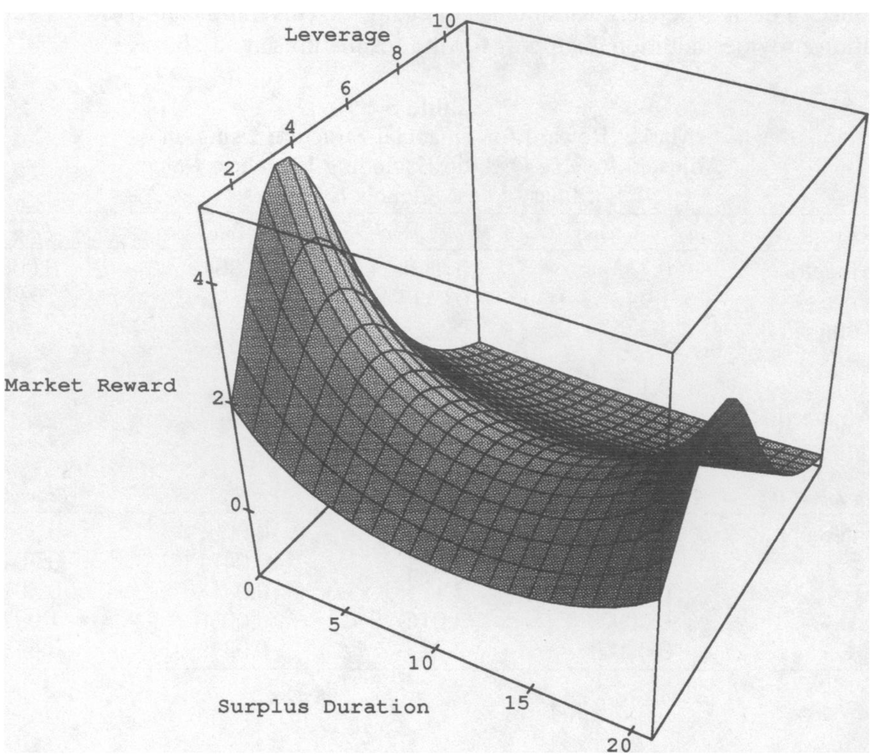
chise value is associated with either more conservative asset-liability management or high levels of exposure to interest rate risk. Although only 33.8 percent of the variation can be explained by the leverage and duration measures, indicating that numerous other factors affect firm value, the overall power of the regression and each t-statistic is significant beyond the 0.0001 level. Individual tests for the impact of leverage (and its square) and duration (and its square) also demonstrate that the effect of each pair can be considered significant beyond the 0.0001 level. The signs and significance of each variable pair (leverage and leverage squared, and duration and duration squared) provide support for a nonlinear structure that, while predicted by theory, has not previously been captured in more common linear models.

Both sets of regression results support the hypothesis of equity value initially increasing with leverage and then falling off rapidly as leverage increases beyond a certain point. This result is consistent with the tax shield vs. cost of financial distress tradeoff discussed earlier. Of perhaps greater interest is the fact that, once this leverage effect has been controlled for, the equity value is initially reduced as surplus duration rises but increases at very high levels of interest rate risk. This finding is consistent with a combination of the hypotheses discussed above—that interest rate risk imposes a cost on the property-liability insurer, but that insurers with low franchise values would choose the strategy of increasing interest rate risk (which is not monitored by regulatory authorities) in an effort to increase equity value. There is clear support for the idea that this multidimensional capital structure is managed in order to maximize the value of the firm while protecting the franchise value of the firm.

Firm management, with access to better information will be able to signal the existence of this franchise value by taking costly efforts to protect it. Alternatively, management by its willingness to increase risk signals a lower franchise value.

The surface mapped by the regression equation (based on the entire data set and including franchise value) is illustrated in Figure 1. The relations regressed on the inverse function are calculated by reinverting the function. The pronounced saddle shape demonstrates the predicted nonlinear relations for both increasing leverage and duration. The range of the independent variables (leverage ranges from 1 to 11 and surplus duration from 0 to 22) was selected to correspond with a reasonable set of possible combinations. The upper bounds were selected by looking at the maximum observed leverage and duration associated with the fourth quintile of duration and leverage, respectively.

Figure 1
Share Prices and Financial Structure
Tobin's Q as a Function of Leverage and Interest Rate Risk
$Q(L,D) = -2 + 1 \div QINV(L,D)$



Although the precise nonlinear form of the relation is not known, the data clearly support the tradeoffs between increasing value (via incentives in the tax structure or increasing volatility that cannot be monitored) and the need to protect the firm from the cost of financial distress. Maximum value is bimodal, associated with medium levels of leverage and either very high or very low levels of interest rate risk.[26] On the leverage axis, value rises steadily through a maximum at approximately four—slightly above the sample average—before declining. The duration axis shows dual maximums, with value highest where interest rate risk is equal to zero—slightly below the observed levels—or, alternatively, at very high levels of interest rate risk.

The inclusion of the calculated franchise value (equity market value minus liquidation value) in the calculation of both leverage and surplus duration introduce measurement error to both sides of the regression equation. The presence of measurement error on both sides of the equation tends to bias the regression coefficients away from zero. The regression is therefore repeated with franchise value excluded from the calculation of leverage and surplus duration, and the results are presented in Table 3. Although the overall fit and significance of each variable is greatly improved by the inclusion of franchise value in the calculation of leverage and duration, the sign and relative importance of each dependent variable is not changed. This more conservative evaluation provides additional support for the results presented above.

Table 3
Market Reward for Financial Structure Using an Adjusted Inverse Q Ratio Excluding Franchise Value: Ordinary Least Squares Estimates

Source	*Sum of Squares*	*Mean Square*	*F-Value*	*Pr > F*
Model	0.333	0.0834	7.304	0.0001
Error	1.942	0.0114		
Total	2.276			
R^2	0.147			
Adjusted R^2	0.127			

Variable	*Estimate*	*t-Statistic*	*Probability*	*Standard Estimate*
Intercept	0.30571	8.024	0.0001	0
L	–0.05216	–2.048	0.0421	–0.7043
D	0.01333	2.171	0.0313	0.6016
LL	0.00921	3.016	0.0030	1.0928
DD	–0.00055	–2.227	0.0273	–0.6583

[26] Given the saddle shape, the maximum q values would be found at extreme levels of interest rate risk. However, extra caution must be exercised when extrapolating the data beyond the ranges of observed data.

Conclusion

Our evidence supports the hypothesis that insurers manage both capital structure (leverage) and interest rate risk (surplus duration) as part of their effort to maximize value and may indeed be signaling the existence of franchise value to outside investors via these actions. Increases in interest rate risk are generally associated with an immediate reduction in the equity market value. This reduction in the equity market value is hypothesized to be related to the inability of shareholders to fully hedge interest rate risk, and to the lower likelihood that they will be able to capture fully the franchise value of the riskier firm. However, some limited evidence indicates that, at high levels of interest rate risk, market value begins to increase. This evidence is interpreted as stemming from the put option value of increasing volatility associated with insurers who are able to expropriate value from policyholders and/or their competitors through state guarantee programs. Marginally solvent insurers or those with low franchise value are able to take advantage of the fact that statutory accounting practices and insurance regulators ignore, and in some sense reward, interest rate risk, and that it is difficult and costly for insurance consumers to obtain credible information regarding an insurer's level of interest rate risk. Franchise value, as measured by Tobin's q, rises at a diminishing rate as financial leverage increases, at least over moderate amounts of leverage. Nevertheless, as leverage continues to rise, the value levels off and then sharply declines. This decline is to be expected given the tradeoff between the tax shield associated with increasing leverage and the costs of financial distress associated with increasing leverage (not the least of which is the increased cost of regulatory interference).

In addition to the obvious managerial implications, our findings have important implications for insurance regulators. One of the primary rationales for the existence of an extensive system of insurance regulation is preventing insolvency and protecting policyholders from loss. Nevertheless, because of their focus on statutory accounting, which allows companies to record assets at book values and liabilities at nominal values, regulators have been unable to measure the level of financial risk at any point in time or to estimate the effect on financial risk when economic conditions change. Statutory practices that rely on these distorted accounting measures create perverse incentives for insurers and can inadvertently reward the risky practices of the very firms regulators should be most concerned about. The cost imposed by an insolvent insurer that is allowed to continue operations for a number of years before statutory insolvency is declared is extremely high. The insurer nearing insolvency has every incentive to increase risk, bet the firm, and hope that it will be lucky.

If leverage is closely monitored and the other sources of risk are not, the incentive to expand these other sources of risk will increase. Other sources of risk include asset risk (e.g., seeking assets that are less liquid or have a lower credit quality), underwriting risk, and interest rate risk. Although it is difficult to obtain a true economic picture of any firm's balance sheet, significant improvement can be made. By collecting the proper information regarding asset and liability structure and their sensitivity to underlying economic factors, regulators would be in a much better position to monitor and control risk.

The National Association of Insurance Commissioners' property-liability insurance risk-based capital formula includes charges for bonds that vary by default-risk class, and the formula's liability charges are based on discounted liabilities. However, the bond charges are levied on the basis of book rather than market values, and there is no charge in the formula for interest rate risk. In addition, it is not clear how closely the discounted reserves approximate market values. Thus, improvements in the formula are likely to be needed to give regulators an accurate indication of the economic value of insurers.

As a final caveat, it is important to note that the validity of the results is based on the quality of the data. The authors recognize that much of the data is imperfect. Every attempt has been made to control for data problems, but we also recognize that the variables are measured with error. In addition, the small sample of publicly-traded property-liability insurers also limits the degree to which the results can be generalized to other insurers or to other industries. The results must therefore be taken as indicative and not as conclusive. Further work, both theoretical and empirical, on the multidimensional aspects of firm financial structure are required before more definitive answers can be given.

Appendix
Modified Taylor Separation Method

In order to convey a better understanding of the specific method, its uses, and its limitations, this appendix reviews the mechanics of the Modified Taylor Separation Method in some detail. As is the case with the original Taylor separation method, the modification is an algebraic system for separating past losses into three factors: tail distribution, loss escalation, and growth in insurance volume. Because the factors are calculated based on real (inflation-adjusted) rather than nominal losses, the method is particularly susceptible to permanent changes in the real rate of interest and to the relation between the term structure and both anticipated and realized inflation rates.

Derivation of the Taylor Separation Method

Taylor's original separation method examines the development of losses on a per-claim basis. For illustration purposes, the following loss development triangle represents the average historical loss per claim for a specified line.

Loss Triangle
Claims Paid

	Development Years			
Accident Year	*1*	*2*	*3*	*4*
1	c_{11}	c_{12}	c_{13}	c_{14}
2	c_{21}	c_{22}	c_{23}	
3	c_{31}	c_{32}		
4	c_{41}			

Each c_{ij} represents the average loss paid in development year j for a loss that was originally incurred in accident year i. The lower triangle (which is blank) represents future loss payments. The present value of the projected losses represents the level of reserves that the insurer should hold in order to pay those future losses. Each diagonal term in the triangle represents payments made in the same calendar year. The size of the triangle is based on the number of years before the final loss is paid. Taylor based his analysis on expected nominal losses on a per-claim basis. His model was designed to calculate the required loss reserve for each claim. By assuming that the percent of losses paid during each development year (the tail) is constant and the impact of inflation is constant for each calendar year, the following two-factor model characterizes the claim process.

Loss Triangle
Development of Tail and Loss Escalation Factors

	Development Years			
Accident Year	*1*	*2*	*3*	*4*
1	$r_1\mu_1$	$r_2\mu_2$	$r_3\mu_3$	$r_4\mu_4$
2	$r_1\mu_2$	$r_2\mu_3$	$r_3\mu_4$	
3	$r_1\mu_3$	$r_2\mu_4$		
4	$r_1\mu_4$			

Here, r_i represents the development tail (i.e., the percent of losses paid in each year following the date of premium payment), and μ_j represents the loss escalation associated with each calendar year. Since 100 percent of the payment is made by the final year (Σr_i = 1.0), the model can be solved recursively to obtain estimates for each r_i and μ_j. By projecting μ_i into the future, and taking the r_is as given, the lower triangle can be completed giving the required nominal reserves per claim. Multiplying the elements of the lower loss triangle by the number of expected claims for each accident year gives the total reserve. The formulas for the tail and loss escalation factors are given below:

Given the loss triangle with elements b_{ij}, let v_j = sum along jth column (j = 0,k), and d_h = sum along hth diagonal (h = 0,k). Then

$$v_j = \sum_{i=1}^{k} b_{ij} = r_i \sum_{l=i}^{k-j} \mu_{j+1} \quad \text{(A1)}$$

$$d_h = \sum_{i+j=h} b_{ij} = \mu_h \sum_{l=0}^{h} r_l. \quad \text{(A2)}$$

A simple factorization yields the values of r and μ:

$$r_i = \frac{v_j}{\sum_{l=1}^{k} \mu_{j+1}} \quad \text{(A3)}$$

$$\mu_h = \frac{d_h}{\sum_{l=0}^{h} r_l} = \frac{d_h}{1 - \sum_{l=h+1}^{k} r_l}. \quad \text{(A4)}$$

Since Σr_l = 1.0, this gives us the initial value for μ_h, and the system can be solved recursively.

The Taylor separation method is purely algebraic. It does not require that the data be on an average claim basis or that nominal values be used. The major assumptions are, first, of some historical consistency in the claims development tail (and an expectation of a similar pattern in the future) and, second, of normalized data points to take account of any changes in the level of business written. Logically, if claims are based on some kind of physical or statistical process, the use of real rather than nominal values should in fact improve the consistency of the data, particularly over long time horizons. Although normalization is preferred using a measure of the expected number of claims, any consistent measure of the number of exposure units can replace it. Nevertheless, if a major change in the overall insurance portfolio composition occurs, calculations based on aggregated lines become convoluted and predictions become increasingly susceptible to error.

Modifications to the Taylor Separation Method

The problem faced by management of the insurer in matching investment assets to loss reserve liabilities is related to the question posed by Taylor, but the focus is changed. First, the management is not interested in calculating the loss per claim, but is interested in the timing and present value of total cash flows related to claims payments. Second, management is interested in understanding how the value and timing of the cash flows will change as interest rates change (since this will affect the value of the assets used to fund such claims). Finally, there is interest in understanding the correlation between the changes in economic values of different classes of investment assets and the economic value of the loss reserves in order to develop a coordinated underwriting and investment strategy. These three concerns can be addressed by a straightforward modification to Taylor's separation method.

The following modifications to the Taylor separation method are proposed due to limitations in the data sources available to researchers. First, a loss triangle containing information from eleven accident years is constructed.[27] The data are adjusted for inflation and then normalized by an estimate of the insurance volume (based on premiums written).[28] This normalized, inflation-adjusted loss triangle is then separated into a set of eleven tail and eleven loss escalation factors. The loss escalation factors are projected into the future using a log-linear regression. With the calculated tail factors, the projected loss escalation factors, and the historical insurance volume, the lower half of the loss development table can be completed. One of the advantages of using the Taylor separation method on data that have been adjusted for consumer price index inflation is that, in addition to the aging effect, the method gives a maximum likelihood estimate of this claims acceleration factor that is then used to

[27] Eleven years represents the maximum data that are available in the annual report. For the development years, the first ten years of development are used and the eleventh year is assigned the value of the unpaid loss reserve in the tenth year.

[28] Insurance inflation and the general consumer price index are not necessarily the same. Nevertheless, it is not clear whether the difference is due to underlying inflation being different (e.g., auto parts and mechanics' salaries inflation being higher than other consumer price components) or the more likely acceleration in the size and frequency of claims payments as liability rules are changed through law and court interpretations. Taylor's methodology is designed to separate these two effects.

estimate the bottom triangle of the claims table. These real factors can then be increased for anticipated inflation and the present value can be calculated using the current term structure.[29] It is also possible to calculate the duration of the liability portfolio and the over- or understatement of reserves for the information contained in the lower half of the loss development table. As new term structures are incorporated into the analysis, new economic values of the reserves are calculated.

[29] This accomplishes the same result as discounting by the real rate of interest. We purposely separate the effect of anticipated inflation from the effect of discounting, as this simplifies the analysis of the sensitivity of changes in one without an offsetting change in the other. The "anticipated inflation" in the calculation is based on the inflation implied by the term structure of interest rates, after subtracting historic inflation differentials.

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