An Exposition of the Implications of Limited Liability and Asymmetric Taxes for Property-Liability Insurance

James R. Garven*

ABSTRACT

This article elaborates upon the intuition underlying Doherty and Garven's (1986) option pricing model and extends its basic results to a further consideration of the implications of limited liability and asymmetric taxes for pricing and risk incentives in property-liability insurance. When compared with CAPM-based models of the insurer, a number of important insights emerge. First, the option pricing framework is shown to encompass the CAPM framework as a special case and may help to explain a number of empirical phenomena. Second, the option pricing framework is used to develop a "risk incentive" hypothesis which suggests that limited liability and asymmetric taxes provide mutuals with greater disincentives for riskbearing than stock companies, even in the absence of owner/manager conflicts.

Although the property-liability insurance industry has been subject to price regulation for many years, researchers have only recently derived valuation formulas for property-liability insurance firms. To date, the most promising approaches apply financial theories such as the capital asset pricing model (CAPM) (see Biger and Kahane, 1978; Fairley, 1979; Hill, 1979; Hill and Modigliani, 1987; and Myers and Cohn, 1987) and the option pricing model (see Doherty and Garven, 1986; Cummins, 1988b; and Derrig, 1989). Although details vary, these models are generally organized around the principle that the rate of underwriting profit must be set so as to produce a "fair," or competitive rate of return on equity.[1]

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* James R. Garven is Assistant Professor of Finance, The University of Texas at Austin. This article has benefited from the helful comments of David Appel, Pat Brockett, David Cummins, Neil Doherty, John Martin, Laura Starks, Rob Walker, Bob Witt, the associate editor, the referees, and seminar participants at The Pennsylvania State University, The University of Pennsylvania, The University of Texas at Austin, and the 1989 Meetings of the American Risk and Insurance Association. The author gratefully acknowledges the financial support of the College of Business Administration Foundation at the University of Texas.

[1] Mention should also be made of the arbitrage pricing model as applied to fair insurance pricing by Kraus and Ross (1982). Like the CAPM, the arbitrage pricing model predicts that the capital market prices only undiversifiable risk. However, unlike the CAPM, the arbitrage

In spite of their common origins, CAPM and option-based insurance pricing models produce substantially different predictions concerning pricing and risk incentives for property-liability insurance. It will be shown that these differences are primarily due to the manner in which the effects of insolvency risk and taxes are modeled. Essentially, CAPM-based models implicitly assume that shareholders have unlimited liability, whereas option-based models assume that shareholders' liability is limited. Similarly, by assuming that losses are rebated at the same rate at which gains are taxed, CAPM-based models effectively assign unlimited liability to the government, whereas option-based models limit the government's liability by assuming that gains and losses are taxed in an asymmetric fashion.

This article elaborates upon the intuition underlying Doherty and Garven's (1986) option pricing model and extends its basic results to a further consideration of the implications of limited liability and asymmetric taxes for pricing and risk incentives in property-liability insurance. This is accomplished by comparing and contrasting option-based with CAPM-based models of the insurance firm. This analysis yields a number of important insights, such as the fact that the option pricing framework encompasses the CAPM framework as a special case. The option pricing model also has several practical advantages over the CAPM. For example, it is not plagued by the CAPM's well-known parameter estimation problems; indeed, it may help to explain the causes of these problems.[2] The option pricing model also provides an explicit linkage between fair return and the risks of insolvency and tax shield underutilization, whereas the CAPM totally ignores these effects.

The option pricing model also calls attention to some important incentive effects concerning risk-bearing that are not captured by the CAPM. Under the CAPM, asset and liability risk is not particularly important so long as these claims are priced to yield appropriate risk-adjusted rates of return. However, under the option pricing model, the extent to which firms will seek to increase or avoid risk through their investment and underwriting policy choices depends upon the likelihood of being taxed or becoming insolvent. Consequently, the application of the option pricing framework makes it possible to develop a "risk incentive" hypothesis which predicts that mutual insurers will seek less exposure to risk than stock companies.

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pricing model allows for the existence of multiple risk factors. Interestingly, the Kraus/Ross arbitrage pricing formula specializes to the Hill (1979) and Fairley (1979) CAPM formulas (see Kraus and Ross (1982, pp. 1021-22)). Although this article focuses upon the more directly comparable CAPM and discrete time option pricing models, the reader should also be aware of the arbitrage pricing model's greater generality compared to the CAPM.

[2] In order to determine appropriate risk loadings, the CAPM requires that an "underwriting beta" be estimated. However, as Cummins and Harrington (1985) have shown, underwriting betas are extremely difficult to calculate with any degree of accuracy. Cummins (1988a) suggests an option theoretic interpretation of these empirical results which shows that the systematic risk of insurance liabilities is likely to be highly nonstationary, depending upon firm-specific factors such as leverage and insolvency risk.

The remainder of this article is organized in the following manner. In the next section, the intuition underlying the use of option pricing theory to model the insurance firm is presented. There, the option and CAPM models are compared and contrasted in terms of their pricing implications, both in the absence and presence of taxes. The third section analyzes the incentive implications of limited liability and asymmetric taxes for stock and mutual organizations. Then, conclusions are presented.

Pricing Implications of Limited Liability and Asymmetric Taxes

General Comments on Options

An option is a financial contract which conveys the right to either buy or sell a particular asset at a given price within a specified period of time. It is not an obligation to buy or sell, but a choice which may be exercised at the option of the holder. Call options derive value from the possibility that the underlying asset can be purchased at some point in time for a price which is less than the market price, thus securing a profit to the holder. Similarly, put options derive value from the possibility that the underlying asset can be sold at some point in time for a price which exceeds its market price.

In their seminal article, Black and Scholes (1973) derive closed form solutions for the prices of call and put options and show how these formulas can be applied to the pricing of corporate securities. The closed form solution for the price of a call option can be characterized as follows:

$$C_0 = C(P_0,X,t,\sigma^2,r), \tag{1}$$

where

C_0 = the current call option price,
P_0 = the current stock price,
σ^2 = the instantaneous variance rate on the stock price,
r = the riskless rate of interest, and
$\partial C_0 / \partial P_0 > 0; \partial C_0 / \partial X < 0; \partial C_0 / \partial r > 0; \partial C_0 / \partial t > 0; \partial C_0 / \partial \sigma^2 > 0.$

Perhaps the most important comparative static relationship (for the purposes of this article) is the effect of a change in the risk of the stock on the price of the call option. An increase in the variance rate affects call option value by making large (positive or negative) stock price changes more likely. However, since the terminal option price is bounded from below at zero, the effect of an increase in risk is to increase the expected payoff on the call option, thereby enhancing its value.[3] Although most of the relationships

[3] Similarly, increases (decreases) in P_0 and r (X and t) enhance call option value by increasing the expected value of its terminal payoff. Most standard MBA-level finance textbooks (e.g., Brealey and Myers (1988)) provide adequate background on the Black-Scholes

between put option prices and parameter values are of opposite sign, the relationship between variance and put option value is positive, as it is in the case of call options.

Payoffs to Insurance Claimholders

It is assumed that the insurance firm is set up at the beginning of the period (t_0) and operated until the end of the period (t_1), at which time all liabilities are either discharged or reserved. At t_0, the insurer receives surplus (equity) and premiums and pays its marketing and production expenses. Thus the initial cash flow is

$$Y_0 = S_0 + P_0, \tag{2}$$

where S_0 = the initial surplus and P_0 = the premiums (net of expenses).

At t_1, allowing for the accumulation of investment income at a rate r_i, the insurer's assets will assume the following value:

$$Y_1 = (S_0 + P_0)(1 + r_i). \tag{3}$$

The No-Tax Case

Next, consider the manner in which Y_1 would be allocated in the absence of taxes. By issuing insurance policies at t_0, shareholders are essentially selling the firm's assets to policyholders in exchange for premium income plus a call option to repurchase the assets at t_1. This call option has an exercise price which is equal to the claims costs (L) which are realized at the expiration date t_1. Consequently, the terminal payoffs to shareholders and policyholders, S_1 and P_1, can be written

$$S_1 = MAX[Y_1\text{-}L,0], \text{ and} \tag{4}$$

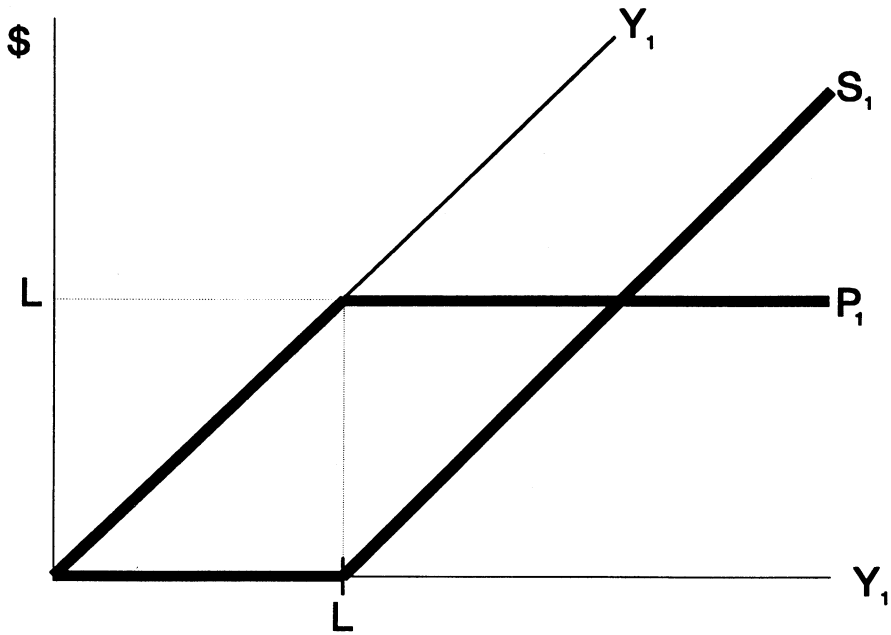
$$P_1 = Y_1 - MAX[Y_1\text{-}L,0]. \tag{5}$$

If assets are worth less than liabilities at t_1 (i.e., if Y_1-$L<0$), then shareholders will rationally choose not to exercise their option to repurchase the firm's assets; consequently, they will default on the policies by allowing policyholders to retain asset ownership. However, if assets are worth more than liabilities (i.e., if Y_1-$L>0$), then shareholders will find it worthwhile to exercise their "in the money" option by making good on the policies. These payoffs are depicted in Figure 1 for a given realization of L.

Closer examination of the payoff to policyholders provides further insight into the pricing implications of limited liability. In equation (5), policyholders are characterized as holding a portfolio consisting of a long position in the terminal value of the firm's assets and a short position in a call option.

formula and its applications. The technically inclined reader may wish to refer to Smith (1976) for a more rigorous treatment of this subject.

Figure 1
Pre-Tax Payoffs to Policyholders (P_1) & Shareholders (S_1)



The application of the put-call parity theorem (see Stoll, 1969; Merton, 1973b) reveals that an equivalent payoff obtains from a portfolio consisting of a long position in a set of safe (default-free) insurance policies and a short position in a "limited liability" put option which gives shareholders the right to sell the firm's assets for what it costs to pay off claims; viz.,

$$P_1 = L - MAX[L\text{-}Y_1, 0]. \tag{6}$$

On the right hand side of equation (6), L represents the payoff on the safe insurance policies, whereas $MAX[L\text{-}Y_1,0]$ represents the payoff on the put option. It is here that the relationship between the option pricing model and the CAPM is the most transparent. Closer examination of the CAPM's characterization of S_1 and P_1 reveals that insurance policies are default-free because shareholders are implicitly assumed to have unlimited liability (i.e., shareholders must pay policyholders $L\text{-}Y_1$ dollars whenever $Y_1\text{-}L<0$). Consequently, under the CAPM,

$$S_1 = Y_1\text{-}L, \text{ and} \tag{7}$$

$$P_1 = L \tag{8}$$

for all possible values of Y_1 and L. Since the CAPM payoff shown in equation (8) stochastically dominates the option payoff shown in equation (6), the CAPM payoff should have a higher value than the option payoff.

In order to facilitate a direct comparison of the pricing implications of the CAPM and the option pricing model, an internally consistent valuation framework must be applied. Two possible approaches exist. The approach taken by Cummins (1988b) is to assume that trading in securities takes place in continuous time as in the original Black-Scholes model. In Cummins' article, the firm's assets and safe policies are priced according to Merton's (1973a) continuous time CAPM, whereas risky policies are priced according to a Black-Scholes-type formula. An alternative discrete time approach is provided by Doherty and Garven (1986), who derive a set of directly comparable CAPM and option formulas using risk-neutral valuation techniques developed by Brennan (1979) and Stapleton and Subrahmanyam (1984).[4] In both the Cummins and Doherty and Garven models, the option pricing framework encompasses the CAPM framework as a special case, since risky policies are equivalent in value to safe policies minus the value of the limited liability put option.[5] Consequently, the option pricing framework is ideally suited for calculating the discount that should be applied to risky insurance policies.[6]

A numerical example is presented next in which the relationship between CAPM and option based insurance prices, and insolvency risk is illustrated. Prices are calculated using versions of the option pricing model and the CAPM which assume that investment returns and claims costs are jointly normally distributed. According to the capital asset pricing models of Fairley (1979), Hill (1979), and Hill and Modigliani (1987), in the absence of taxes, the "fair" price for insurance (P_0) is given by equation (9):

$$P_0 = E(L)/(1-E(r_u)), \tag{9}$$

where $E(r_u) = -kr_f + \beta_u[E(r_m) - r_f]$, k is the claim delay, and β_u is the underwriting beta. For the sake of simplicity, a value of unity is assigned to $E(L)$ and k and zero to β_u. This implies that $E(r_u) = -r_f$ and $P_0 = 1/(1+r_f)$. Assigning a value of 7 percent for r_f results in a CAPM price of \$.9345. Since the CAPM implicitly assumes that the insurer's shareholders have unlimited liability, this price is independent of the level of surplus invested

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[4] Restrictions on the stochastic properties of asset prices are required by both the continuous time and discrete time approaches. In the continuous time model, such restrictions make it possible to price options *as if* investors are risk neutral. In the discrete time model, preference restrictions are also required. Brennan (1979) shows that constant absolute (relative) risk aversion must be assumed when the price of the underlying asset is normally (lognormally) distributed. Stapleton and Subrahmanyam (1984) extend Brennan's results to the pricing of options with stochastic exercise prices. This latter finding is especially important, since insurance contracts have stochastic exercise prices.

[5] A similar claim is made by Brennan (1979, p. 65), who suggests that "...by appropriate specification of the payoff on the contingent claim it is possible to analyze problems arising from default risk ... within a traditional capital asset pricing framework."

[6] The option pricing framework is also ideally suited for calculating risk-based guarantee fund premiums, since the value of the insurance guarantee is equal to the value of the limited liability put option (see Cummins, 1988b).

in the firm. The CAPM price is represented by the horizontal line in Figure 2 for surplus values ranging from \$3 to \$.10.

A comparable set of prices for the option model can be obtained by solving Doherty and Garven's equation (19) (1986, p. 1038), subject to the fair return criterion given by their eighth equation, for surplus values ranging from \$3 to \$.10 and a tax rate (τ) of zero.* This calculation requires the specification of five additional parameter values:

(1) standard deviation of claims costs (σ_L) = \$.40,
(2) market risk premium ($E(r_m)$-r_f) = 8 percent,
(3) standard deviation of market return (σ_m) = 20 percent,
(4) correlation between investment returns and claims costs (ρ_{iL}) = 0, and
(5) beta of insurer's investments (β_i) = 1.

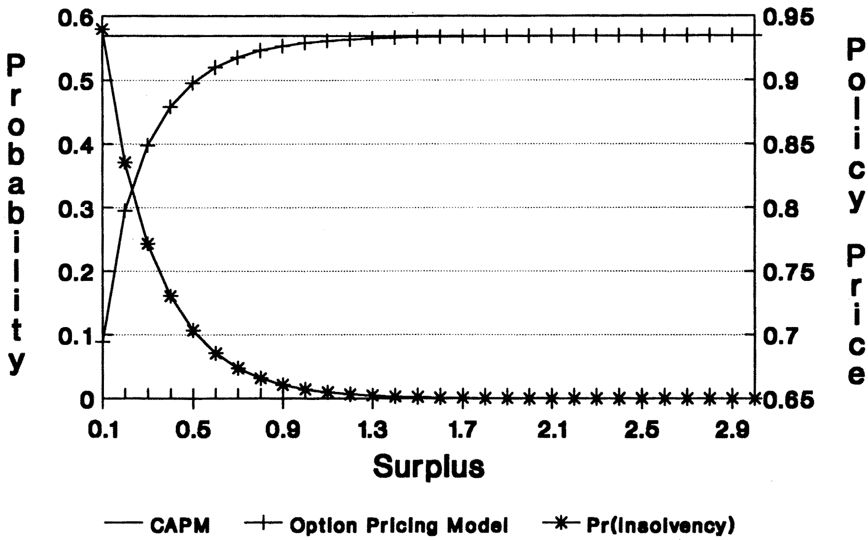
These values were chosen from various sources. The standard deviation of claims costs (σ_L) is based upon the coefficient of variation of the ratio of incurred loss plus loss adjustment expenses to surplus for the U.S. property-liability insurance industry between 1926 and 1985 (see Best's *Aggregates and Averages*). The market risk premium (($E(r_m)$-r_f)) and standard deviation (σ_m) are close to what Ibbotson and Sinquefield (1986) report for the same 60 year period. A value of zero for ρ_{iL} is implied by the earlier assumption that β_u = 0.[7] Finally, β_i=1 is chosen arbitrarily.

Under the option model, the level of surplus is important because it affects the value of the limited liability put option. Since the value of this option is positively related to the probability of insolvency, a decrease (increase) in surplus increases (decreases) the put's value by increasing (decreasing) insolvency risk. In Figure 2, it can be seen that for very high levels of surplus, the prices indicated by the CAPM and option model are identical. This is due to the fact that the limited liability put option is worthless when the probability of insolvency is negligible. However, as the level of surplus declines, the probability of insolvency increases, which causes the put option to increase in value. The value of the put is obtained by subtracting the price indicated by the option model from the price indicated by the CAPM. In this example, the put ranges in value from \$0 for surplus of \$3 to \$.31 for surplus of \$0.10. The corresponding difference in $E(r_u)$ indicated by the CAPM and option models ranges from zero for the safe (surplus = \$3) firm to -.37 for the most risky (surplus = \$.10) firm. This difference essentially reflects a risk premium paid to policyholders for bearing insolvency risk.

* See my "summary of required changes."

[7] A correlation of zero is implied so long as the relationship between investment returns and claims costs can be adequately accounted for by the relationships these variables have in common with the market; see Doherty and Garven (1986, p. 1036, fn. 8) for a further elaboration of this assumption.

Figure 2
CAPM vs. Option Prices: The Effect of Default Risk



The Effect of Taxes

Taxes complicate the analysis. Tax shields are created whenever the insurer incurs losses from either its investment or underwriting activities. Furthermore, it is a common practice for insurers to shelter at least a portion of their investment income from taxation by purchasing tax-favored financial assets such as municipal bonds and common stocks. Therefore, depending upon whether the insurer is profitable, it is possible for some of these tax shields to be underutilized. Although insurers can apply current losses against past income, past income may not fully offset loss carrybacks. When this occurs, losses are carried forward at a zero rate of interest, and beyond a certain point in time, carryforwards that are not utilized expire. Consequently, the tax shield per dollar of loss is worth less than the tax liability per dollar of gain because loss carryforwards do not earn interest, and the firm may not produce adequate income to use the loss carryforwards before they expire. In the limiting case where tax loss carrybacks or carryforwards are disallowed, the government's claim upon the firm's future income can be modeled as a portfolio of call options, one on each year's taxable income.

Without loss of generality, taxes will be examined in a single period framework.[8] Firms which purchase tax favored financial assets are

[8] By using a single period model, the possibility of the insurer making use of tax loss carrybacks and carryforwards (as would be the case in a multi-period framework) is not

obligated to pay taxes on the taxable portion (q) of the change in the value of their assets from t_0 to t_1, as well as on underwriting profits. The firm's end of period tax liability is therefore defined as

$$T_1 = \tau[\theta(Y_1\text{-}Y_0) + (P_0\text{-}L)], \tag{10}$$

where τ is the statutory corporate income tax rate. Substituting (2) and (3) into (10) yields

$$T_1 = \tau[Y_1\text{-}TS], \tag{11}$$

where $TS = L + S_0 + (1\text{-}\theta)r_i(S_0+P_0)$. This is essentially the manner in which after-tax versions of the CAPM (e.g., Fairley, 1979; Hill and Modigliani, 1987) define the firm's tax liability. By defining the tax liability in this manner, CAPM models implicitly assume that the government shares equally in the firm's gains and losses by receiving T_1 dollars whenever $T_1 > 0$ and rebating T_1 dollars whenever $T_1 < 0$.

However, because the government is unwilling to share equally in the firm's gains and losses for tax purposes, equation (11) must be rewritten

$$T_1 = \tau MAX[Y_1\text{-}TS,0]. \tag{12}$$

In equation (12), the government can be characterized as holding a fractional position in a call option on Y_1, the exercise price of which is equal to TS. The payoff to this option is depicted in Figure 3 for a given realization of L. There, it is important to note that 1) TS is greater than L,[9] and 2) when Y_1 exceeds TS, the slope of the government's payoff equals the tax rate τ.

Consequently, in the presence of taxes, terminal payoffs to shareholders and policyholders under the option pricing model are rewritten in the following manner:

$$S_1 - T_1 = MAX[Y_1\text{-}L,0] - \tau MAX[Y_1\text{-}TS,0], \text{ and} \tag{13}$$
$$P_1 = L - MAX[L\text{-}Y_1,0]; \tag{14}$$

whereas the CAPM payoffs are rewritten as:

$$S_1 - T_1 = Y_1 - L - \tau(Y_1\text{-}TS), \text{ and} \tag{15}$$
$$P_1 = \text{L}. \tag{16}$$

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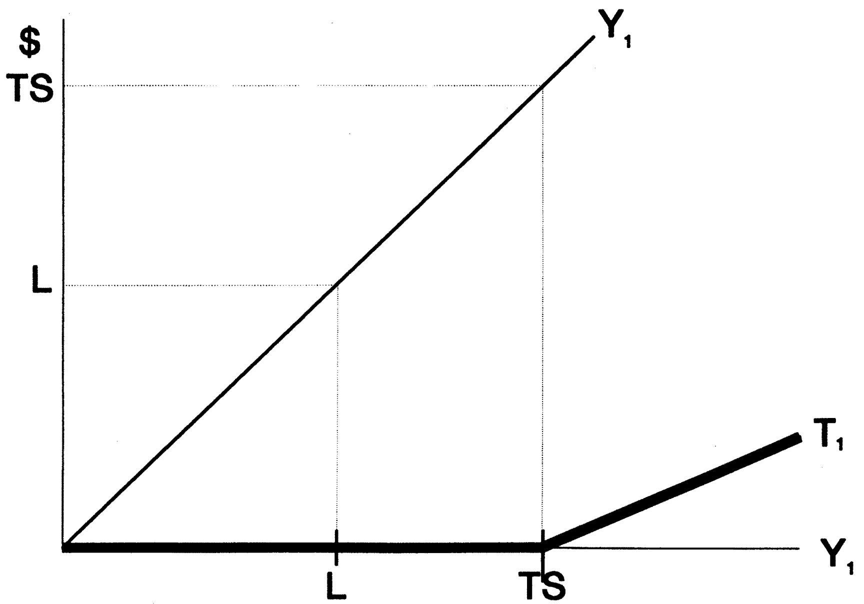
formally considered here. While the effect of this provision is to reduce the burden of tax shield underutilization, its inclusion would not substantially alter the basic results of the model presented here. See Majd and Myers (1984) for numerical estimates of the effects of the carryback-carryforward provision for nonfinancial firms.

[9] In principle, it is possible for TS to be less than L. However, this is very unlikely, in that most firms would have to expect to earn arbitrarily large negative investment returns well beyond the experience of the industry in order for this to occur. Interested readers may request an appendix from the author which demonstrates this fact both analytically and empirically.

Figure 3
Payoff to the Government (T1)



A comparison of equations (15)-(16) with equations (13)-(14) reveals that the payoffs assumed under the two models coincide only when $Y_1 > TS$. When $L < Y_1 < TS$, the CAPM assumes that the government rebates $\tau(Y_1 - TS)$ dollars to the firm, whereas the option model assumes that the firm receives nothing. Finally, when $Y_1 < L$, the CAPM assumes that shareholders pay policyholders $L - Y_1$ dollars, whereas the option model assumes that policyholders suffer a shortfall of $L - Y_1$ dollars. The application of an internally consistent valuation framework reveals once again that the option pricing framework encompasses the CAPM framework as a special case.[10] Although shareholders must pay taxes under either model, in a competitive market the tax burden is shifted to policyholders in the guise of higher premiums than would be the case in the absence of a corporate tax. If shareholders bore the tax burden, there would be an outflow of capital away from the insurance industry, since returns to capital invested in this industry would no longer be competitive.[11] Furthermore, the tax burden is even greater under the option pricing model due to the fact that the payoff to the government is bounded from below at zero; i.e., the government doesn't provide tax rebates.

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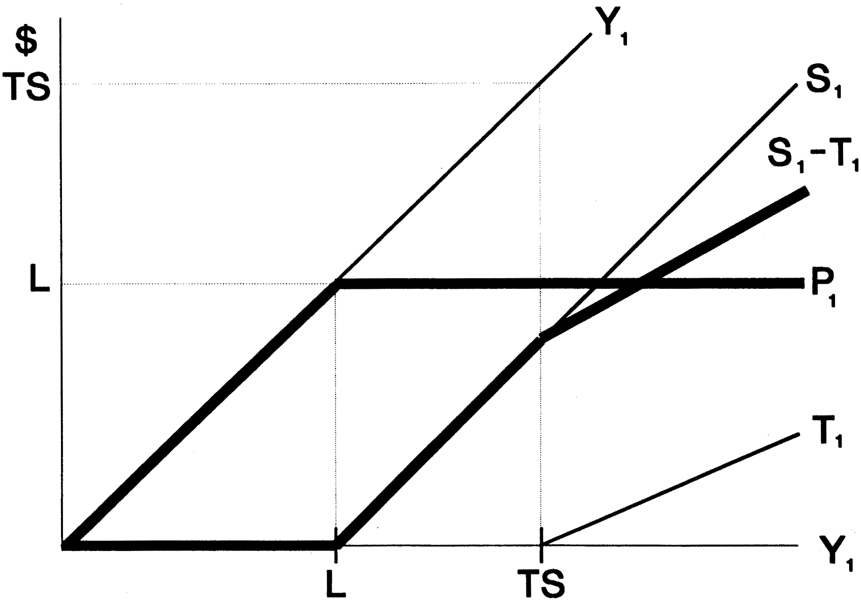
[10] Specifically, if parameter values were chosen such that $Pr[Y_1 - TS < 0] = 0$, both models would generate the same prices for shareholders', policyholders' and the government's claims.

[11] This is implied by virtually all insurance pricing applications of the CAPM. See Myers and Cohn (1987) for an alternative development of this argument.

The after-tax payoffs to shareholders and policyholders described in equations (13) and (14) are depicted in Figure 4 for a given realization of L. The effect of taxes is to proportionately decrease shareholder payoffs whenever Y_1 exceeds TS. Interestingly, the after-tax payoff to shareholders (represented by the piecewise-linear function labeled S_1-T_1) resembles the payoff to shareholders of an untaxed insurer issuing participating policies which allow policyholders to purchase a fraction, t, of the equity whenever the terminal value of the firm exceeds TS.

Figure 4
After-Tax Payoffs to Policyholders (P1) and Shareholders (S1-T1)



A numerical example is presented next in which the relationships between the after-tax CAPM and option pricing models and their pre-tax counterparts are illustrated. According to the capital asset pricing model of Hill and Modigliani (1987), in the presence of taxes, the expected return on underwriting is

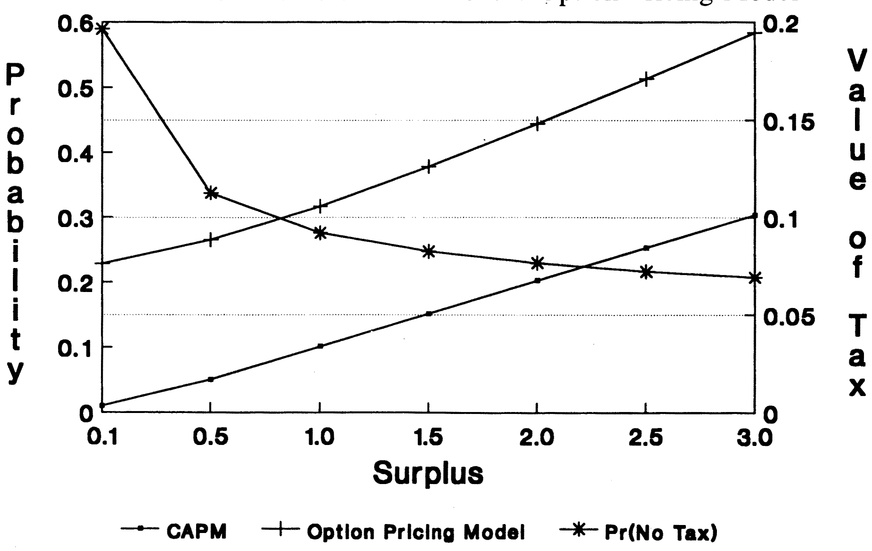
$$E(r_u) = -kr_f(1\text{-}\theta\tau)/(1\text{-}\tau) + \beta_u[E(r_m) - r_f] + (S_0/P_0)r_f(\theta\tau/(1\text{-}\tau)). \qquad (17)$$

In equation (17), the time value component (kr_f) is modified for differential tax effects arising from the manner in which investment and underwriting income is taxed. Furthermore, the firm's tax liability is related to the amount of surplus (S_0) that it commits to underwriting policies. As described earlier, in a competitive market this incremental tax burden is borne by policyholders in the guise of higher premiums than would be the case in the absence of taxes.

In the following numerical example, a value of unity is assigned to θ, τ is assumed to be 34 percent, and all other parameter values from the previous example are assumed to apply. Consequently, equation (17) specializes to $E(r_u) = -r_f + (S_0/P_0)r_f(\tau/(1-\tau))$, which is Fairley's (1979) solution for the expected after-tax return on underwriting.[12] The after-tax CAPM price is calculated by inserting solutions for equation (17) into equation (9). Equation (17) implies that when taxes are considered, the CAPM price will be functionally related to the level of surplus; specifically, the lower the surplus, the lower the price. If the firm invests solely in fully taxed securities (i.e., if θ=1), then the after-tax CAPM price converges toward the pre-tax CAPM price as the level of surplus becomes negligible. This is shown in Figure 5, where the value of the government's claim under the CAPM ranges from \$.1012 for surplus of \$3 to \$.0034 for surplus of \$.10.

Figure 5

The Value of Taxes: CAPM vs. the Option Pricing Model



The numerical values for the after-tax option model were obtained by applying the same solution procedure as before, using a tax rate of 34 percent rather than zero. Under the option pricing model, a qualitatively similar relationship exists between the level of surplus and taxes as under the CAPM; i.e., surplus is undesirable in the sense that its presence

[12] Fairley's after-tax CAPM is a special case of the Hill-Modigliani CAPM, in that Fairley assumes that θ=1; viz., insurance companies do not purchase tax-favored investments. When θ=1, the tax effect captured in the term $-kr_f(1-\theta\tau)/(1-\tau)$ cancels out, leaving only the tax effect associated with the level of surplus. Of course, if θ=0, then the Hill-Modigliani formula specializes to Fairley's pre-tax formula described earlier; viz., $E(r_u) = -kr_f + b_u[E(r_m) - r_f]$.

increases the firm's expected tax liability. However, by imposing a lower bound of zero on the payoff to the government, the option pricing model incorporates an additional tax effect that is ignored by the CAPM; specifically, changes in the level of surplus affect the probability of tax incidence. Therefore, a decrease in surplus increases the probability that the firm will be untaxed as well as insolvent. These effects are shown in Figure 5. The value of the government's tax option is calculated by subtracting the after-tax option price from the pre-tax option price. In this particular example, the tax option ranges in value from $.1946 for surplus of $3 to $.0762 for surplus of $0.10. Also, regardless of the level of surplus, the value of the government's claim as determined by the option pricing model always exceeds the value of the government's claim as determined by the CAPM.[13]

A Brief Digression on Specific Provisions of the Tax Reform Act of 1986: Due to the Tax Reform Act of 1986, the nature of the payoff to the government has changed substantially. Although the statutory tax rate has been lowered from 46 percent to 34 percent, the insurance industry's tax burden is greater under the new law. Regulations concerning the manner in which loss reserves are discounted and unearned premium reserve offsets are treated effectively lowers the exercise price of the government's tax option, thereby rendering it more valuable. Furthermore, the alternative minimum tax (AMT) causes the tax status of certain classes of tax favored financial assets (such as municipal bonds and common stocks) to be modified under certain circumstances. These tax law changes are accommodated within the option pricing framework by changing the specification of the terminal payoff on the tax option shown in equation (12) to the payoff given in equation (18):

$$T_1 = MAX[\tau(Y_1\text{-}TS),\tau'(Y_1\text{-}TS'),0], \tag{18}$$

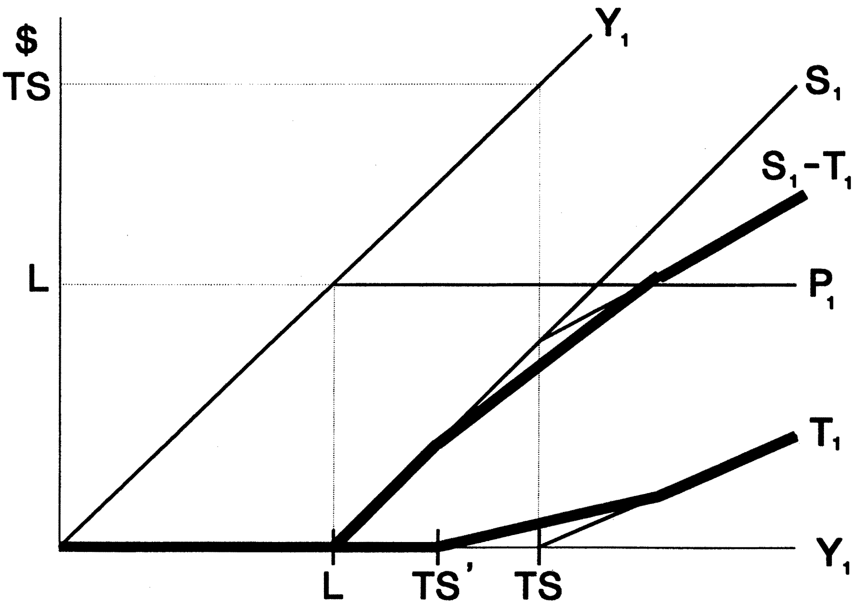
where t' is the alternative minimum tax rate (currently 20 percent) and Y_1-TS' corresponds to alternative minimum taxable income. Depending upon the relative magnitudes of the investment returns and claims costs realized by the firm, it may or may not be subject to the alternative minimum tax. The probability of incurring the alternative minimum tax is highest for poorly capitalized firms which write long tailed lines of business and invest primarily in tax favored assets. Also, the alternative minimum tax is more

[13] The corresponding tax-related differences in $E(r_u)$ are: The after-tax CAPM value for $E(r_u)$ is .1045 greater than its pre-tax value when surplus is $3, compared to a difference of only .0038 when surplus is $.10. Under the option pricing model, the after-tax value for $E(r_u)$ is .1844 greater than its pre-tax value when surplus is $3, compared to a difference of .1423 for surplus of $.10.

likely to be incurred by firms experiencing poor investment and/or underwriting results.[14]

Figure 6 depicts the effect (holding L constant) of the alternative minimum tax on the payoffs to the government and the shareholders. There, it can be seen that the primary effect of the alternative minimum tax is to increase the number of states of the world in which the firm pays taxes, thereby increasing the value of the government's tax option.[15] Also, the alternative minimum tax has the effect of decreasing the convexity (concavity) of the payoff to the government (shareholders).

Figure 6
Effect of the AMT on Payoffs to the Government and Shareholders



Incentive Implications of Limited Liability and Asymmetric Taxes

Apart from its pricing implications, the option pricing model calls attention to a number of predictions concerning risk incentives that are not captured by the CAPM. In the previous section of the article, CAPM-based models were shown to implicitly assume that both shareholders and the government have unlimited liability. Although this assumption makes it

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[14] These relationships are based upon numerous sensitivity analyses performed by the author, and are available upon request. The reader is also referred to Gleeson and Lenrow (1987) for a detailed analysis of the effects of the Tax Reform Act of 1986 on property-liability insurers.

[15] Since the Tax Reform Act of 1986 significantly increases the value of the government's claim on insurers' incomes, an empirical study of the effects of the 1986 act upon the share prices of publicly traded stock insurers should reveal significantly negative abnormal returns. Furthermore, the magnitude of the negative returns should be related to the probability of the incidence of the alternative minimum tax, as described above.

possible to price end-of-period payoffs using the CAPM, arbitrage arguments establish that the value of the insurer in such a setting is independent of the manner in which it manages its asset and liability risks. Since shareholders can hypothetically replicate any risk management decision made by the firm, the CAPM predicts that shareholders will be indifferent concerning alternative investment and underwriting policy choices. However, under the option pricing model, shareholders' portfolio decisions are no longer perfect substitutes for corporate decisions due to the effects of limited liability for shareholders and the government. Therefore, depending upon the likelihood of being taxed or becoming insolvent, insurers may rationally seek to either increase or reduce risk by making appropriate risk management decisions. Consequently, the application of the option pricing framework makes it possible to develop a "risk incentive" hypothesis which suggests that limited liability and asymmetric taxes provide mutuals with greater disincentives for riskbearing than stock companies.

In the discussion that follows, the risk incentive hypothesis is developed from a thorough consideration of the incentive implications of limited liability and asymmetric taxes for mutual and stock insurers. The discussion is concluded with a brief survey of corroborating empirical evidence.

Incentive Implications of Limited Liability

Although the legal rule of limited liability provides a number of important benefits, it also has its costs (see Easterbrook and Fischel, 1985). The most obvious cost relates to the fact that limited liability creates a moral hazard by rewarding shareholders with all of the benefits of risky activities but penalizing them with only a portion of the costs.[16] This aspect of limited liability is readily captured within the option pricing framework. Earlier, it was noted that the convex payoff to shareholders of an untaxed insurance firm resembles the payoff on a call option. Since the value of a call option is positively related to the level of risk, so is the value of the firm's stock. Consequently, in the presence of insolvency risk, shareholders may be tempted to increase the risk of the organization, thereby redistributing wealth from policyholders to themselves.[17]

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[16] Indeed, this very aspect of limited liability has led other researchers (e.g., Munch and Smallwood, 1981) to question whether stock insurers face adequate incentives to invest any capital whatsoever. However, Finsinger and Pauly (1984) conclude that costly bankruptcy may provide incentives for adequate capital, even in a world in which the demand for insurance is price inelastic with respect to insolvency. Garven (1987) reaches similar conclusions based upon tax and agency cost considerations.

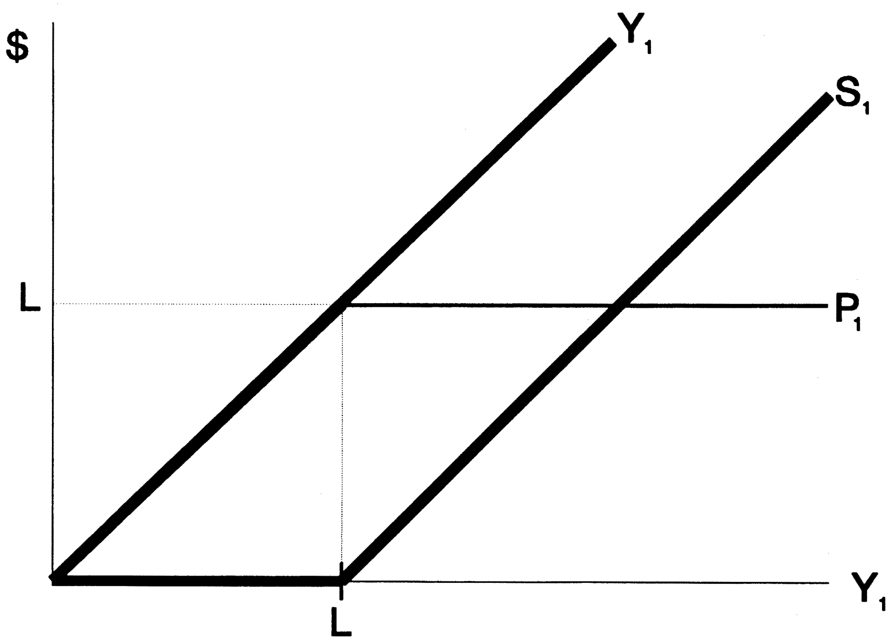
[17] This result obtains even if shareholders are otherwise risk averse. Although risk preferences are of paramount importance in determining the market value of the firm's assets, it is well known that the pricing relationship between an option and its underlying asset is preference-independent (see Cox and Ross (1976)).

Mayers and Smith (1988) note that one way to resolve this conflict in incentives between policyholders and shareholders is to impose a mutual ownership structure. By assuming ownership of the firm's equity, policyholders fully reap the benefits as well as assume the costs of the firm's risk management decisions. Consequently, the wealth redistribution effects which result from the convexity of the equity claim under the stock ownership structure are eliminated. By rendering the value of the policyholders' claims invariant to changes in the riskiness of the firm, the mutual ownership structure causes owners to be indifferent concerning the risk characteristics of alternative investment and/or underwriting policy choices.

Owners' payoffs under the stock and mutual forms of organization are depicted in Figure 7 for a given realization of L. There, the convex payoff schedule denoted as S_1 represents the payoff to owners if the firm is organized as a stock corporation, whereas the linear payoff schedule denoted as Y_1 represents the payoff to owners if the firm is organized as a mutual.

Figure 7

Payoffs to Mutual and Stock Owners in the Absence of Taxes

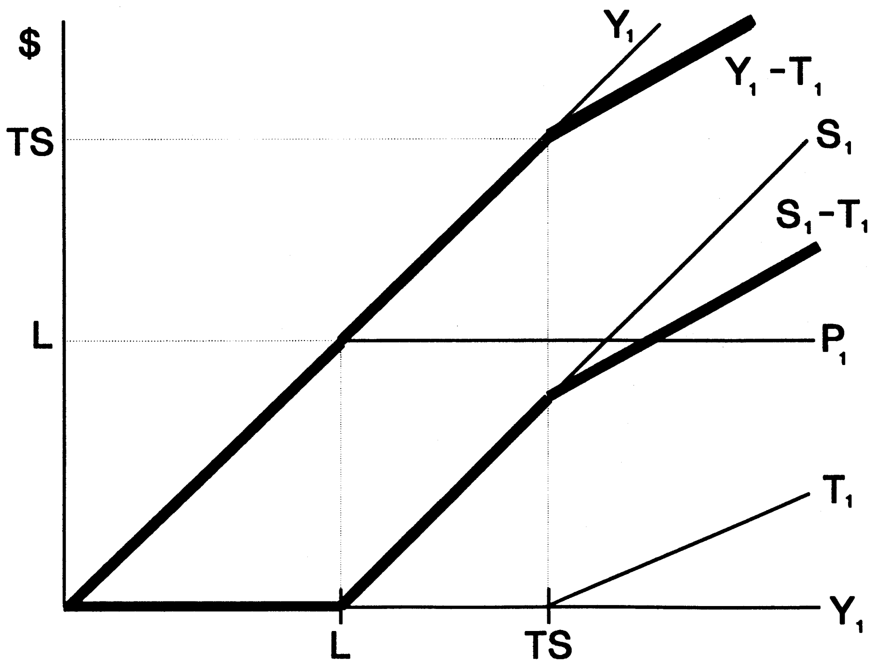


Incentive Implications of Asymmetric Taxes

The previous analysis demonstrated that limited liability provides stock insurers with an incentive to maximize risk exposure, whereas risk exposure will be a matter of indifference to mutual insurers. However, asymmetric taxes modify these incentives rather substantially.

Consider the case of a mutual insurance firm. The firm's owners (policyholders) are held liable for tax payments. Consequently, in the presence of taxes, the policyholders of a mutual company hold a long position in the terminal value of the firm's assets and a short position in the government's call option. The payoff to this claim, Y_1-T_1, is depicted in Figure 8 for a given realization of L. The presence of asymmetric taxes induces some degree of risk aversion insofar as investment and underwriting policy choices are concerned, since expected tax payments are increasing in the variability of taxable income. Other things held constant, policyholders will seek to reduce risk, since decreases in risk transfer wealth from the government to policyholders.

Figure 8
Payoffs to Mutual and Stock Owners in the Presence of Taxes



While asymmetric taxes render risk incentives for mutual insurers unambiguous, the same cannot be said for stock insurers. The after-tax payoff to shareholders, S_1-T_1, is also depicted in Figure 8 for a given realization of L. For stock insurers, risk incentives are ambiguous because the payoff is convex over the tax exempt region of the firm's cash flows (i.e., when $Y_1 \leq TS$)) and concave over the solvent region (i.e., when $Y_1 \geq L$)). While limited liability provides an incentive for increasing risk, asymmetric taxes simultaneously provide an incentive for reducing risk. Therefore, the risk exposure chosen by a stock insurer depends, among other things, upon the likelihood of being taxed as opposed to becoming insolvent.[18] Taxes

[18] If it is unlikely that the firm will become insolvent, then the risk incentives for mutual and stock insurers are similar (absent or present taxes). Alternatively, if it is unlikely that the firm

moderate the temptation for risky firms to increase risk, whereas limited liability weakens incentives for profitable firms to decrease risk. However, since the payoff to mutual owner-policyholders is globally concave while the payoff to stock owner-shareholders is locally convex and concave, the analysis suggests that mutuals have greater financial incentives for reducing risk than do stock companies.

One final point should be made concerning the risk incentive effects of the corporate tax code. As noted earlier, the Tax Reform Act of 1986 increases the value of the government's tax option by imposing an alternative minimum tax. However, since the alternative minimum tax also reduces convexity (as shown in Figure 6), the value of the tax option is rendered less sensitive to changes in risk. Consequently, although mutuals will still seek to bear less risk than stock companies under the new law, the incentives for avoiding risk under both ownership structures is somewhat weakened.[19]

The above analysis demonstrates that the propensity for mutuals to bear less risk than stock companies is a natural consequence of the legal and tax systems under which insurance firms operate. Although the possibility of incentive conflicts between owners and managers was not considered, the inclusion of such conflicts further reinforces these results. Since mutuals are likely to experience more significant managerial control problems than stock companies, Mayers and Smith (1988) hypothesize that owners of mutual firms will attempt to impose greater limitations upon the discretion that can be exercised by management.[20] Their managerial discretion hypothesis predicts, among other things, that mutual insurers will 1) underwrite fewer lines of insurance than stock insurers and be more prevalent in lines of insurance which afford less managerial discretion in evaluating and rating risks, and 2) concentrate their investments in assets for which accurate indices of value are available. Empirically, the managerial discretion hypothesis predicts that mutuals will choose less risky assets and liabilities than stock companies and is therefore in general agreement with the risk incentive hypothesis developed here.

The above analysis also implicitly assumes that the *cause* of asymmetric taxes, viz., tax shield underutilization, is an important problem for insurers.

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will pay taxes, the limited liability effect dominates, giving rise to the same prediction for stocks versus mutuals as under the no-tax case. Since the limited liability and tax effects offset each other, there may exist some firms whose incentives to change risk are neutralized because the marginal changes in the values of the pre-tax option and tax option are equal.

[19] The degree of risk aversion depends upon the convexity of the payoff on the tax option. Ironically, by aligning the interests of shareholders and policyholders of risky firms, asymmetric taxes may give rise to potential welfare gains in the form of the conservation of monitoring resources.

[20] It is generally believed to be more costly to control managerial behavior in a mutual than in a stock company because shareholders can rely upon the threat of an unfriendly takeover to discipline managers, whereas mutual policyholders must rely upon a less effective and inherently more expensive control mechanism, the proxy fight.

There currently exists a debate in the corporate finance literature concerning whether this risk can be adequately hedged through financial contracts, or whether tax shield risk actually influences the firm's investment and financing decisions. Green and Talmor (1985) argue that the shareholders of a levered firm will have an incentive to underinvest in risky assets so as to avoid underutilizing tax shields. In their analysis, the investment decision is the only mechanism available for hedging this risk. MacMinn (1987) shows that if the firm is able to hedge its tax shield risk with financial contracts, then the investment incentive effects described by Green and Talmor can be neutralized. However, Campbell and Kracaw (1990) argue that if risk is not completely observable, then firms may have incentives to alter their investment and financing decisions, since financial contracts can effectively hedge only those risks which are either directly observable or highly correlated with directly observable risks.[21] Certainly casual empirical evidence suggests that tax shield underutilization is a very real problem in the economy. For example, Heaton (1987) notes that the fact that 40 to 60 percent of all U.S. corporations in recent years have paid no taxes lends credibility to the assertion that a full tax-loss offset does not always exist for corporations; i.e., taxes are asymmetric. Heaton's observation would appear to be particularly relevant to property-liability insurers in view of the fact that the industry paid approximately zero net federal income taxes during the 25 year period preceding the Tax Reform Act of 1986 (see Walker, 1991).

Although the body of empirical research concerning risk management decisions of stock versus mutual insurers is somewhat limited, the evidence that has been produced to date is generally consistent with the predictions of both the managerial discretion and risk incentive hypotheses. Specifically, it appears that mutual insurance companies tend to adopt more conservative investment and underwriting strategies than do stock insurers.[22] Mutuals have been found to concentrate a larger proportion of their investments in financial assets and smaller proportions in non-financial assets than stock insurers (see Fama and Jensen, 1983). After controlling for size, stock companies write relatively more business in riskier lines of insurance (see Lamm-Tennant and Starks, 1992) and reinsure less (see Mayers and Smith, 1990) than mutuals.[23] Finally, stock insurers also tend to be more highly

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[21] Although risks associated with trading securities in public markets are for the most part directly observable, insurers may be subject to various other sources of risk which are not. Examples of risks which may be "unobservable" in the Campbell and Kracaw sense might include investment risks associated with private placements and direct investments, as well as claims risks arising from the firm's underwriting activities.

[22] Similar results have been found for other types of financial institutions. For example, Rasmusen (1988) cites historical evidence dating back to the 19th century which shows that mutual banks have tended to hold safer asset portfolios and have lower failure rates than stock banks.

[23] Mayers and Smith find that widely-held stock insurance companies cede proportionately less reinsurance than any other ownership class, including mutuals. Although they also find

leveraged and bear more interest rate risk than mutuals (see Doherty and Garven, 1990).

Summary and Conclusion

CAPM-based models of insurance pricing can be generally viewed as special cases of option-based models. So long as an internally consistent valuation framework is applied, prices under the option model converge toward CAPM prices as the probabilities of insolvency and tax shield underutilization become negligible. The option model also has several important practical advantages over the CAPM. First, the option model gets around some peculiar difficulties related to parameter estimation and as noted earlier, may help to explain the causes of such problems. Second, the option model provides a scientific basis for quantifying the tradeoff between fair return and insolvency risk.[24] Third, the option model explicitly models the effects of underutilized tax shields. The numerical calculations presented here reveal that this can have a major effect, and may help to explain why CAPM-based models tend to underestimate actual profit levels.[25]

This article also calls attention to some important implications of the option pricing framework for the analysis of risk incentives faced by mutual and stock organizations. The well-known propensity for mutuals to bear less risk than stock companies is interpreted within this framework as a natural consequence of limited liability and asymmetric taxes. Although owner/manager incentive conflicts also are likely to play an important role in the determination of the risk exposures of insurance organizations, this article shows that mutuals would bear less risk than stock companies even in the absence of owner/manager conflicts.

weak evidence that single-owner stock insurers reinsure more than mutuals, this is to be expected since risk aversion is more likely to be an important motivating factor for closely-held than for widely-held firms.

[24] In view of the current momentum of voter and legislative initiatives throughout the United States for significant rollbacks in insurance rates, the need for understanding this tradeoff has obviously become especially important recently.

[25] For example, Hill (1979) compares after-tax CAPM-based estimates of underwriting profit rates for the period between 1955 and 1974 with historical realizations and concludes that regulation has resulted in excess profits for the insurance industry. However, perhaps some of these "excess profits" may be due to the failure of the CAPM to account for the effect of underutilized tax shields during this period. See D'Arcy and Garven (1990) for corroborating evidence.

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