Insurance Cycles: Interest Rates and the Capacity Constraint Model

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Insurance profits exhibit cyclical behavior that has been attributed to capital market constraints. We show that changes in interest rates simultaneously affect the insurer's capital structure and the equilibrium underwriting profit. Depending upon asset and liability maturity structure, capital market access, and reinsurance availability, insurers will be differently affected by changing interest rates. We find that the average market response to changing interest rates roughly tracks market clearing prices. These "cyclical" effects are enhanced for firms with mismatched assets and liabilities and more costly access to new capital and reinsurance. This evidence supports the capacity constraint hypothesis.

I. Introduction

It is widely believed that insurance markets are cyclical. The supporting evidence relates primarily to the accounting measures used by insurers to record their underwriting profits.[1] Underwriting returns appear to follow a second-order autoregressive process with a period averaging about 6 years. This "underwriting cycle" is both persistent and pervasive, being observed over long time periods (see Smith 1980; Venezian 1985; and Doherty and Kang 1988) and in many countries (Cummins and Outreville 1987). Moreover, similar cycles have been observed in other financial institutions. For example, bank earnings are cyclical and are related to interest rate

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[1] One possible explanation for the cycle is that it is an accounting fiction; the accounting measure of underwriting profit simply fails to reflect the underlying economic value. As Watts and Zimmerman (1986, pp. 144–46) have noted, the time-series properties of accounting numbers can be altered substantially depending on the choice of accounting method. They cite an example in which "smoothing" transforms a deterministic earnings series into a reported series that conforms to a random walk.

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changes in a manner that lags the general business cycle. Furthermore, Flannery and James (1984) have found that commercial bank and savings and loan (S&L) stock returns are significantly related to interest rate changes. They find the strength of this interest rate sensitivity is directly related to the maturity mismatch of bank assets and liabilities.

As noted by Grøn (1989, 1994) and others, explanations for the insurance cycle can be divided into several broad camps. In one set of explanations, simple models of insurer behavior are developed in which feedback mechanisms are used to induce autoregressive return series. For example, Brockett and Witt (1982) and Venezian (1985) show that setting prices around loss forecasts generated from previous loss experience is capable of generating autocorrelated underwriting returns. Similarly, Berger (1988) develops a model in which insurance capacity depends on the current level of equity that, through retained earnings, is determined largely by pricing decisions made in the previous period.[2] This process may again be sufficient to produce an autoregressive process for underwriting returns. Cummins and Outreville (1987) show that simple lags in data collection or price regulation may be sufficient to produce cyclical performance even in a rational expectations setting.

A second explanation builds on the fact that the "underwriting profit" represents a measure of the average price of the contracts traded.[3] Insurance pricing models based on financial theory are unanimous in showing that competitively determined insurance prices are inversely related to interest rates and will therefore change as interest rates change.[4] Using this model, together with the rational expectations and lag features of the Cummins and Outreville model, Doherty and Kang (1988) show that the intertemporal behavior of underwriting returns in insurance markets is quite well explained as a market clearing process in which equilibrium prices change in lagged response to changing interest rates. This explanation for insurance cycles parallels that for banking cycles noted earlier.[5]

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[2] In the insurance literature, insurer equity is often referred to as "surplus." These terms will be used interchangeably throughout the article.

[3] Underwriting profit, as noted later, is essentially a measure of the rate of return earned from issuing insurance policies.

[4] To date, the most promising financial theoretic approaches apply the capital asset pricing model (CAPM; see Biger and Kahane 1978; Fairley 1979; Hill 1979; Hill and Modigliani 1987; and Myers and Cohn 1987), the arbitrage pricing model (Kraus and Ross 1982), and the option pricing model (see Doherty and Garven 1986; Cummins 1988; Derrig 1989).

[5] However, insurance markets are "different" in the sense that, while general economic fluctuations do indeed track the fluctuations in the insurance cycle, *unanticipated* changes in variables such as gross domestic product (GDP), inflation, and interest rates do not cause significant changes in insurance underwriting returns (see Grace and Hotchkiss 1995).

A third explanation focuses on external shocks to the value of the insurer's equity and therefore to its underwriting capacity. These models sometimes are called "capacity constrained" models. Harrington (1988), Winter (1988, 1991, 1994), Grøn (1989, 1994), and Cummins and Danzon (1991) show that, given limited liability and costs to raising external capital, sudden shocks to insurers' liabilities can generate price and quantity effects such as those observed over the insurance cycle.[6]

The three approaches outlined above have been presented as competing models. The feedback/lag models have little to say concerning the exogenous factors that clearly have a bearing on insurance markets, although the feedback mechanisms are useful in other models. The main prediction is simply that insurance prices are autocorrelated; thus tests have little discriminatory power between the feedback/lag model and competing models. The interest rate model may be classified as a present value model,[7] and its main prediction is that insurance prices reflect expected payouts capitalized at the current cost of capital. While frictions are anticipated in this model, it does not address the role of insurer capacity and therefore is silent about the observed relationship between insurance cycles and insolvencies noted by Grøn and others. Further, this model does not well explain the severe disruptions associated with the liability crisis in the mid-1980s. By contrast, the capacity constrained models do a good job in explaining the liability insurance crisis and the response of the insurance market to catastrophic storm and earthquake losses in the late 1980s. Explicitly or implicitly, these models adopt a present value notion of insurance prices, though the main prediction is that this relationship will be disturbed by the effects of equity shocks. These models are the most complete; but, in focusing on capital constraints, the full implications of changes in the cost of capital on insurance prices have not been exploited. In short, the present value model best explains the relationship between interest rates and insurance prices that has persisted over many decades,[8] whereas the capacity constrained model

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[6] Liability "shocks" may be caused by any number of factors, such as hurricanes, earthquakes, and dramatic changes in tort liability rules.

[7] Two important implications of the interest rate, or present value models, are (1) underwriting margins should inversely reflect current interest rate levels and (2) insurance premiums should constitute informationally efficient predictors of future claims costs. The very existence of a cycle in underwriting returns would appear to be inconsistent with the second implication. If insurance markets were informationally efficient, then the underwriting return errors should be completely random and certainly not autoregressive in nature.

[8] Even if one uses alternative measures of performance, such as the economic loss ratio (see Winter 1991), this relationship persists. Winter's measure is highly correlated with the return on underwriting. The troughs and peaks in Winter's ratio correspond almost perfectly with those for the return on underwriting.

best explains the sudden crises that periodically beset the insurance market.[9]

Our reasoning suggests that there are gains to be realized from joining these strands of the literature. The mechanism for doing so is straightforward. When interest rates change, they affect not only the equilibrium price for a default-free insurance contract, but they also change the market value of the insurer's asset portfolio (which is typically composed of mostly fixed income, interest-sensitive assets). In addition, the insurer's liabilities also are sensitive to interest rate changes (as our data will show) as well as being vulnerable to catastrophic events and changing liability rules. Thus, insurers are subject to shocks to surplus through both the asset and liability sides of their balance sheet. Moreover, and this is fundamental, the asset shocks (and to some extent the liability shocks) coincide with changes in the equilibrium prices of the default-free insurance contracts. This fact immediately makes sense of (apparently) rival empirical results. For example, while Doherty and Kang show that insurance cycles are closely related to interest rates, Grøn, Winter, and Cummins and Danzon show that the cycle is related to insurer capacity.

Joining the interest rate and capacity constrained models provides an opportunity for a different empirical approach. Absent capacity effects, interest rate changes should produce changes in underwriting returns of the opposite sign. However, the capacity effects of the same interest rate changes will affect insurers differently according to the interest sensitivity of their asset and liability portfolios and according to differences in their respective costs of raising new capital. The first cross-sectional difference can be measured by asset and liability durations and the second difference by organizational factors such as ownership structure, size, whether public or privately traded, and so on.

II. Insurance Pricing Models

A. *Insurance Pricing Models without Default Risk*

Evidence for the insurance cycle is usually presented as a time series for underwriting returns accompanied by anecdotal evidence on availability and changes in insurance premiums. The rate of return on underwriting, r_u, is defined as the insurer's aggregate premiums P, net of

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[9] That no single model is sufficient to explain the cycle may explain Tennyson's (1990) empirical results. She uses cross-sectional tests to discriminate between two broad competing explanations of the insurance cycle (autocorrelated expectations vs. lagged adjustment). Her evidence is somewhat mixed. Large, purportedly efficient firms exhibit underwriting return series that are consistent with the lagged adjustment model. Smaller firms, however, appear to make systematic errors in estimating their loss exposures.

expenses X, minus aggregate incurred losses L, expressed as a percentage of premiums:[10]

$$r_u = \frac{P - L}{P}.$$

It is well known that the aggregate premium for an insurance portfolio is the discounted value of the expected nominal loss on the portfolio. Thus, in a single period setting, $P^* = E(L)/(1 + r)$, where r is the nominal interest rate per period (see Kraus and Ross 1982).[11] A simple rearrangement of this formula reveals that the expected underwriting return in a competitive market will equal the negative of the discount rate used to capitalize the expected loss, and it will change as nominal interest rates change (time subscripts are omitted):

$$E(r_u) = \frac{P^* - E(L)}{P^*} = -r.$$

The insurance literature has sought to establish the appropriate discount rate and to provide an appropriate representation of the temporal process by which claims are generated. For our purposes, it is sufficient to note that these models predict that, over time, expected rates of underwriting return will vary inversely with interest rates. An important general feature of these models is that the sensitivity to interest rate fluctuations will be greater for those lines of insurance where claims are settled long after premiums are collected (such as product liability and medical malpractice) than for quickly settled lines (such as property and automobile liability insurance). For our purposes, these features are conveniently captured in the CAPM-based models such as those of Biger and Kahane (1978), Fairley (1979), and Hill (1979). In the absence of taxes, the expected underwriting return is

$$E(r_u) = -kr_f + \beta_u\lambda, \qquad (1)$$

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[10] This measure turns out to be similar to the return measure used by Grøn (1994, eq. [1]) if expenses are ignored. Moreover, since expenses relative to premiums are fairly stable over time (Doherty and Kang 1988), the return on underwriting as defined above and Grøn's return measure display the same autoregressive features and are therefore close substitutes for the current analysis.

[11] The use of nominal value for losses and interest rates can be explained as follows. Consider that L_0 is the estimated settlement amount if losses are paid when the premiums are paid. But losses are paid with some delay, since accidents can happen anytime during the policy year, and, after the accident, the settlement of the claim with the insurer may take some time. The expected inflation of losses over the settlement period is $E(I_L)$. The real rate of interest is r_r and the expected rate of inflation for the economy as a whole over the same time period is $E(I)$. Thus, the premium can be stated as $P^* = E(L_0)(1 + E(I_L))/(1 + r_r)(1 + E(I))$. This simplifies to $E(L_0)/(1 + r_r)$ only if claims' costs are expected to inflate at the same rate as overall inflation. Whether this is the case or not, we can simply use both nominal values for losses and interest rates (see Kraus and Ross 1982).

where k is the average time taken to settle claims, β_u is the underwriting beta, r_f is the risk-free rate, and λ is the market risk premium. Thus, assuming that the underwriting beta and the market risk premium are constant through time, then expected returns on underwriting respond to interest rates as follows:

$$\frac{dE(r_u)}{d(kr_f)} = -1. \tag{2}$$

The sensitivity of underwriting returns to interest rate changes is determined by the average settlement delay, k. Accordingly, cross-sectional differences in k between insurers should be associated with differences in the response of underwriting returns to interest rate changes. This relationship is predicated on the assumption that the interest rate changes do not affect the insurer's leverage, either because it is perfectly hedged or because perfect capital markets ensure instant and costless replacement of lost equity. These assumptions are now relaxed in the capacity constrained models.

B. Default Risk and the Capacity Constrained Model

Several models recognize that the prospect of insurer default is related to the equity of the insurer. These models show how shocks to surplus result in short-term price and quantity responses. The class of such models includes (*a*) those that show the short-run market clearing prices that result from surplus shocks (Grøn 1989, 1994; Winter 1988, 1991, 1994; and Cummins and Danzon 1991) and (*b*) an alternative implicit contract model in which surplus shocks are followed by short-run price rises and quantity rationing (Doherty and Posey 1993). Our empirical work shown below will exploit the common prediction of these models: that surplus shocks result in short-run price increases.[12] Since we do exploit a common prediction, we will motivate our empirical work here simply by reference to the Grøn and Winter models and by integrating these models with equation (1).

Consider a loss of insurer equity caused by unanticipated claims or by a fall in the value of the insurer's assets. The immediate consequence is to increase the insurer's leverage; had the insurer's capital structure been in an acceptable range, it will now find itself overleveraged. A small loss of equity can be replaced through internal sources such as retained earnings, but replacement of large equity losses requires access to external capital markets. Since external capital is more costly than internal capital, sudden large shocks to capacity will shift

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[12] While these models have a common prediction, they can be distinguished empirically. The Doherty/Posey model predicts rationing responses, whereas the Grøn and Winter models predict market clearing. Empirical work by Doherty and Posey shows discriminating tests of the models.

the insurer's short-run supply curve (see Grøn 1989, 1994; Winter 1988, 1991, 1994). The insurer will prefer to operate temporarily at a suboptimal capital structure and to adjust slowly to its optimum through retained earnings. As the short-run supply curve shifts to the left through a large capacity shock, prices will rise and the volume of insurance traded will fall.

An important feature of the models of Grøn and Winter is that the preference for internal capital, combined with a given probability of insolvency, generates a particular shape to the short-run supply curve. With such a supply curve, they are able to provide an explanation of several features of recent insurance crises. For any given level of equity, there is a limit on the number of policies that can be sold at a fixed price without increasing the probability of insolvency. Beyond this limit, the price has to increase in order to maintain the same level of insolvency risk. Thus, the supply function is kinked, being elastic for quantities below the kink and inelastic thereafter. With this feature, they are able to explain why insurance markets exhibit price stability given modest shocks to surplus, but become quite unstable when the shock surpasses a critical value. Examples of such reactions include the medical malpractice crisis in the 1970s and the more general liability insurance crisis in the 1980s.

The Grøn and Winter model is illustrated in figure 1. Shocks (i.e., reductions) to surplus shift the supply curve to the left and, depending on the size of the supply shift and the position of demand, the short-run premiums will either rise or remain stable.[13] In turn, as Grøn (1994, p. 115) points out, "Variations in relative capacity affect the underwriting margin through short-run premiums." Thus, the capacity constrained model may be summarized by the predicted *short-run* relationship between accounting or underwriting return (margin) and the insurer's equity Q—$dE(r_u)/dQ \leq 0$.

In examining shocks to surplus, the principal focus of Winter, Grøn, and Cummins and Danzon was on shocks to liabilities caused by catastrophic claims or revisions in loss reserves. We shift the focus to consider the effects of interest rate changes on insurer equity. The relevant property is the duration of the insurer's equity, D_Q. If duration

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[13] Grøn and Winter focus on the effects of capacity shocks on the supply curve. Thus, a negative shock to equity will shift short-run supply to the left and will reduce the quantity traded, which may or may not be accompanied by a price increase. Cummins and Danzon (1991) and Doherty and Garven (1991) note that the price and quantity effects of such a shock could be ambiguous. If demand is sensitive to the probability of insolvency (i.e., if insureds can monitor the condition of insurers and are not protected by insolvency guarantees), then the demand curve also will shift to the left. While the predicted price effect is ambiguous, the demand effects will be secondary for consumers that are well protected by the state insurance guaranty schemes. We evoke this reasoning to endorse the prediction of Grøn and Winter that insurance prices are (weakly) positively affected by shock to equity.

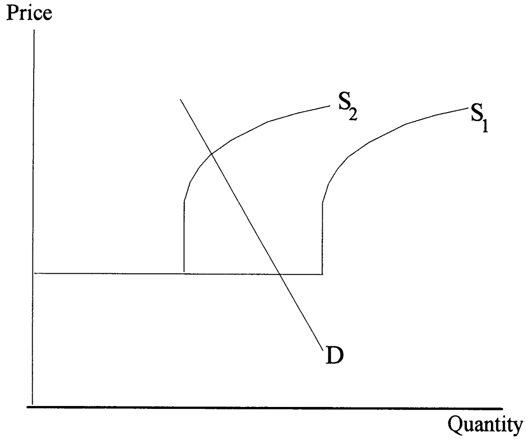

FIG. 1.—The Grøn-Winter model

is positive, then the value of equity increases as interest rates fall and vice versa; that is, $dQ/dr_f < 0$ (> 0) if equity duration is positive (negative). A special case arises when the insurer is able to manage its duration by cross-hedging its asset and liability portfolios. In this case, equity is protected from interest rate changes: $dQ/dr_f = 0$. Running interest rate changes through the capacity constrained model—$dE(r_u)/dQ \leq 0$—yields the following *short-term* effects of interest rate changes (recall that the long-run effect as described in equation (1) is $dE(r_u)/dkr_f = -1$):

$$\frac{dE(r_u)}{d(kr_f)} = \frac{\partial E(r_u)}{\partial Q}\frac{\partial Q}{\partial(kr_f)}\begin{cases} \geq -1 & \text{if surplus duration is positive,} \\ = -1 & \text{if surplus duration is zero,} \\ \leq -1 & \text{if surplus duration is negative,} \end{cases} \tag{3a}$$

$$\frac{dE(r_u)}{d(kr_f)} = f(D_q);\text{ where } f' > 0, \tag{3b}$$

where D_Q is equity duration. In turn, equity duration depends on the respective durations of the assets and liabilities and on leverage of the firm. Babbel and Staking (1989) show that, in the absence of default risk, the relationship between the duration of equity and that of assets, D_A, and liabilities, D_L, is given by

$$D_Q = (D_A - D_L)[V(A)/V(Q)] + D_L, \tag{4}$$

where $V(A)/V(Q)$ is the ratio of the value of the insurer's assets to its equity.

The explanation for equations (3a) and (3b) is as follows. An increase

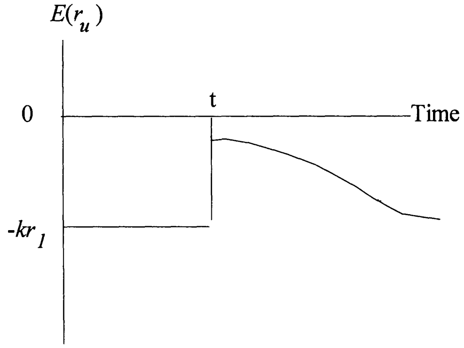

FIG. 2.—The Grøn-Winter model

in interest rates causes equilibrium underwriting returns to fall, as shown by equation (2). The same change in interest rates, however, will change the value of the insurer's equity: the higher the equity duration, the larger the fall in the value of the insurer's equity. Assuming that transaction costs are incurred in replacing lost surplus, firms with higher equity duration will exhibit a more pronounced shift in the short-run supply curve shown in figure 1, and they will display greater increases in short-run prices. On the contrary, firms that hedge asset and liability durations (such that equity has a zero duration) will not display such short-run price changes.

Figures 2–4 now illustrate the synthesis of the Grøn-Winter model with the interest rate model. In Figure 2, we illustrate the effects of a loss of surplus caused by a sudden increase in insurer claims at time t (e.g., due to a severe hurricane or earthquake). Since the loss of surplus is not related to interest rate changes, the long-run equilibrium return is not changed from its existing level of $-kr_1$. However, the temporary increase in leverage will cause the short-run supply curve to shift to the left, thereby causing a short-run increase in price as shown in figure 1. As time passes, lost equity will be replaced (e.g., through retained earnings) and the supply curve will converge on its prior position. Accordingly, returns will again converge to their pre-shock level of $-kr_1$ as shown in figure 2. The interest rate model is illustrated in figure 3. This figure shows the effects of a change in interest rates on underwriting return, assuming that the interest rate change does not affect surplus (i.e., the insurer has hedged interest risk). At time t, interest rates rise from r_1 to r_2 and the underwriting return changes instantaneously from $-kr_1$ to $-kr_2$. Figure 4 relaxes the assumption that the interest rate leaves equity unaffected. Now, the rise in interest rates changes the long-run equilibrium return from $-kr_1$ to $-kr_2$. If we assume equity duration to be positive, however, the increase in leverage prevents immediate return adjustment to $-kr_2$.

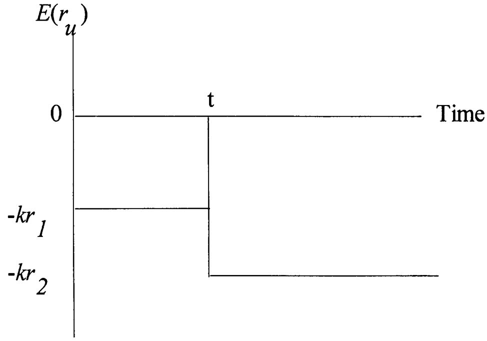

FIG. 3.—The interest rate model

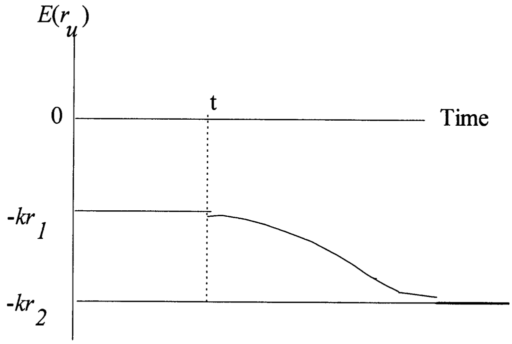

FIG. 4.—Synthesis of Grøn-Winter with interest rate models

The adjustment will follow a path such as shown in figure 4 with short-run returns above the new long-run equilibrium. The magnitude of this displacement from the new long-run equilibrium depends on duration as shown in equations (3) and (4).

In addition to the duration effects, differential transaction costs of raising capital can give rise to cross-sectional differences in short-run return responses to interest rate changes. We will use various proxies to measure transaction costs. We expect publicly traded stock firms to have lower transaction costs than private firms do for raising new equity. Similarly, we expect publicly traded stock firms as a whole to have lower transaction costs than do mutual insurers. In a similar vein, we expect that large firms are able to raise new capital more cheaply than small firms can. Our final proxy for transaction costs relates to reinsurance. Insurers can readjust leverage, not by changing their equity, but by selling liabilities to other insurers, that is, by reinsuring. Changing the net volume of reinsurance sold, however, is costly. In addition to the usual brokerage charges, such transactions involve all the information costs associated with new insurance transactions (see D'Arcy and Doherty 1990). Accordingly, we predict that $dE(r_u)/d(kr_f)$ is higher for firms with more costly access to reinsurance markets.

Summarizing, we predict that firms will exhibit cross-sectional variation in the responsiveness of their underwriting returns to changes in interest rates:

$$\frac{dE(r_u)}{d(kr_f)} = f(\underset{-}{\text{QDUR}}, \underset{+}{\text{PUBLIC}}, \underset{+,-}{\text{PRIVATE}}, \underset{+}{\text{REINS}}, \underset{+}{\text{SIZE}}), \tag{5}$$

where

QDUR = equity duration;
PUBLIC = 1 if publicly traded, 0 if private or mutual;
PRIVATE = 1 if privately held, 0 if public or mutual;
REINS = measure of reinsurance access; and
SIZE = firm size.

The above predictions can be supplemented by a secondary set of predictions. Responses to rising and falling interest rates are unlikely to be symmetric. As interest rates rise and bond prices fall, insurers are faced with the question of whether to float new equity. Raising new equity involves explicit transaction costs (e.g., underwriting fees) as well as the adverse selection costs arising from information asymmetry between insurance management and external investors.[14] Similar transaction costs arise if the insurer responds not by raising equity but by increasing its ceded reinsurance.[15] If the insurer finds itself underleveraged due to a fall in interest rates, it is less costly to adjust to its desired capital structure. The distribution of equity through dividends is less costly than the raising of new issues. Similiarly, the reduction in the net value of reinsurance ceded is likely to be less costly than an increase.[16] The extreme case of asymmetry is the case of mutuals where the cost of raising capital in the short run (i.e., above

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[14] See Myers and Majluf (1984) for a general discussion of this cost and Winter (1988) and Grøn (1989) for some applications to insurance.

[15] For example, a new reinsurance contract encounters the costs of information asymmetry between the ceding and reinsuring firms.

[16] The assumption implicit here is that the transaction costs from reinsurance transactions (including those due to information asymmetry) are borne by the ceding firm. Such an assumption is consistent with most models of adverse selection in competitive insurance markets in which information costs are borne by the policyholder in general or some subset thereof (see, e.g., Rothschild and Stiglitz 1976). For example, if the firm responds to underleverage by assuming more reinsurance, one would expect the transaction costs to be borne by the ceding firm. If the firm responds by reducing the amount ceded to reinsurers, then the firm may simply let existing treaties lapse.

immediate earnings) is, theoretically, infinite. However, the mutual is perfectly free to distribute equity to its policyholders whenever it sees fit to do so. The asymmetry can be detected by including a squared term as follows:[17]

$$r_{ut} = \alpha_0 + \alpha_1(kr_{ft}) + \alpha_2(kr_{ft})^2 + \epsilon_t, \tag{6}$$

where $\alpha_1 < 0$ and $\alpha_2 > 0$.

Before leaving this section, it may be noted that surplus shocks can arise in other ways. In addition to interest rate changes, equity can be affected by catastrophic losses such as hurricanes or earthquakes. Each would cause loss payments to exceed amounts reasonably reserved. Similarly, unanticipated inflation would have a similar effect on realized loss payments. Such effects would reduce equity in much the same way that an increase in interest rates would reduce bond values. Similar reasoning suggests that the reduction in the value of equity would trace through to the product market and would be revealed in price and quantity changes.

III. Empirical Results

A. Aggregate Time Series Results

The first task in the empirical section of this article is to see whether the time series of underwriting returns can be explained simply from the spot equilibrium prices required to deliver to the insurer a fair rate of return on equity. This result would be consistent with the notion that the cycle is a purely monetary phenomenon. The simplest test of this hypothesis is suggested by equation (2). The following equation is estimated using generalized least squares (GLS).[18] The independent variable is the average settlement delay, k, times the weighted average

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[17] A similar effect may result from leverage regulation. State regulation restricts the choice of leverage ratios. Although there is no strict limit, premium to surplus ratios in excess of 3:1 usually attract regulatory scrutiny through the insolvency early-warning system. If this ratio is treated as binding, then similar asymmetries would be likely. Interest rate rises, which increase the premium to surplus ratio, would bring increasing numbers of insurers to the 3:1 effective constraint, and, barring new equity issues, these insurers would tend to respond by reducing the quantity of insurance sold. While rising interest rates would reduce the *equilibrium* rate of underwriting return, the excess demand resulting from capacity shortage would temper the fall in underwriting return. Interest rate falls would be accompanied by rising bond prices and reduced leverage and would not capture regulatory attention. One would expect that the effects of interest rate changes would be asymmetric, with rising rates causing moderate falls in underwriting return (with excess demand) and falling rates producing more vigorous increases in underwriting returns.

[18] Estimation of this relationship using ordinary least squares (OLS) produces residuals that display first- and second-order autocorrelation. The GLS procedures were used to correct this problem.

of monthly spot Treasury-bill rates (rather than daily rates that were unavailable over the entire period of the analysis, 1939–88).[19]

$$r_{ut} = \alpha_0 + \alpha_1(kr_{ft}) + \epsilon_t. \tag{7}$$

A word on the expected values of the coefficients will be helpful. The interest rate is a Treasury-bill rate used as a proxy for the riskless rate of interest. If the risk premium required on the underwriting contracts is stable over time, the intercept term α_0 will provide an estimate of the risk premium. If an asset pricing model (such as the capital asset pricing model or the arbitrage pricing model) was used to generate the appropriate risk premiums, then clearly their value would depend on the correlation between underwriting profit and the market portfolio (or priced factors). Most empirical work (see, e.g., Cummins and Harrington 1985) suggests that such betas are small or not significantly different from zero. If this were the only term in the intercept, we would expect the intercept to be fairly close to zero. The intercept might, however, embody other factors, such as various tax effects and the costs of restrictions on investment choice (see D'Arcy and Doherty 1988, p. 45). We simply expect the intercept to have a positive value.

Second, the slope parameter, α_1, should be insignificantly different from negative unity if policies are continually priced at their *current* competitive level as suggested in Section II. A slope of negative unity implies that competitive rates of return on equity are expected at all phases of the cycle in underwriting profit and is consistent with the view that there is no capacity fluctuation over the cycle. A slope in excess of -1.0 suggests that in the insurance market there are frictions that prevent the insurer from adjusting leverage. Accordingly, interest rate increases are followed by supply cutbacks—that is, excess demand for insurance—and interest falls are followed by excess supply.

The GLS regression result is based on underwriting results for all

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[19] Though insurance returns are accounted on an annual basis, new policies are written throughout the year. The pricing eq. (1) suggests that *expected* underwriting returns will mirror nominal interest rates *at the time contracts are written* (in turn, nominal interest rates will reflect contemporaneous inflation expectations). Thus, the prices of contracts written during a 1-year period will reflect a *weighted average* of the interest rates prevailing at the time each contract was written; the weights representing the distribution of new policies throughout the year. Losses are recorded following the end of the accounting year. Some losses are actually paid, and these will reflect actual inflation between the time the contract was written and the time the claim was paid. Losses outstanding at year-end will be reserved, and the reserve contributions also will reflect actual loss inflation through the year. If expectations concerning loss inflation are unbiased, revealed losses will differ from initial expectations (held at the time the contract was written) by a randomly distributed error. Thus, we regress realized losses against the 1-year nominal interest rates that prevailed at the time during which the contracts generating those losses were written. The error term picks up unanticipated loss inflation together with other noise in the realization of losses.

U.S. property-liability lines written by stock companies for the 50-year period 1939–88:

$$\underset{(4.013)}{r_u = 4.8390} - \underset{(-4.945)}{0.7570\,(kr_f)}.$$

The adjusted R^2 is .8137, and the Durbin-Watson (D-W) statistic is 1.9419. The slope differs from −1.0 at the 6% significance level.

Averaged over a very long period and over all insurance lines, the insurance market responds to changes in the capital market rates broadly; as one would predict, interest rate increases reduce the rate of underwriting profit.[20] The fact that the estimated slope coefficient exceeds negative unity is consistent with the presence of capacity constraints. This interpretation requires some caution. The data available for estimating the average settlement delay, *k*, are not ideal. In particular, we do not have discounted values for insurer's loss reserves. This implies that the values used for *k* are too high and the slope coefficient is probably overestimated. Given this caution, we look for other evidence of capacity constraints.

While the above result should dispel the view that fluctuating underwriting profit per se is evidence of a dysfunctional market, the result is highly aggregated and it is possible responses might differ between firms, between lines or perhaps over different stages of the cycle. For example, the simple model described by equation (1) with no capacity constraints would predict symmetric sensitivity to rising and falling interest rates. Thus, the inclusion of a squared term, $(kr_f)^2$, to distinguish rising from falling rates should have little effect, and the coefficient for this term should not differ significantly from zero. By contrast, if capacity and related imperfections are present, then nonlinear responses are predicted as described in the previous section and as shown in equation (6). The result shows evidence of this predicted asymmetry, with underwriting profit being significantly more responsive to falling rates than to rising rates.[21]

$$\underset{(4.556)}{r_u = 6.3587} - \underset{(-3.616)}{1.4185(kr_f)} + \underset{(1.782)}{0.0383(kr_f)^2}, \qquad \begin{array}{l} R^2 = 0.8258, \\ \text{D-W} = 1.8446. \end{array}$$

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[20] A sufficient, but not necessary, condition for this prediction is that the equity duration is positive. This is indeed the case for most of the firms in the sample discussed in Sec. III*B* below, and thereafter. During the period 1981–86, 270 of the 277 firms in our cross-sectional study had positive equity durations. Consequently, for most firms, a rise (fall) in interest rates will typically lead to a fall (rise) in the value of equity.

[21] The direction of the asymmetry is inconsistent with another commonly cited view of underwriting cycles. Consider that there is some restriction on premium changes. The obvious case would be regulation on prices or underwriting profit. The expected consequences would be for price rises to be constrained by regulation but for price falls to be unconstrained. With such a regime, the slope parameter for rising interest rates should be higher (in absolute value) than that for falling rates. This result shows exactly the opposite effect.

There is some further anecdotal evidence that is consistent with this interpretation of the asymmetric response. Insurer insolvencies have been concentrated in periods of low underwriting profitability, at least in recent cycles (see, e.g., Grøn 1989). But this observation and the previous result, while consistent with the capacity model developed here, do not provide a strong test of that model. To provide a more rigorous test, we look to individual firm data. This will enable us to see whether cross-sectional differences in the responses of different firms to changing interest rates correlate with differences in equity duration and access to external capital.

B. Cross-Section Analysis: Data and Methodology

A panel consisting of year-end data from 1976–88 for 277 property-liability insurers was constructed from Balance Sheet–Income Statement, Premiums-Losses-Expenses, and Schedule P summary tapes produced by the A. M. Best Company. The criteria applied in the selection of the sample were (1) the firm must have complete data for the period 1976–88; (2) the firm must be organized as either a stock or mutual company; and (3) the firm must either be a group or unaffiliated single company. Furthermore, since a number of variables used in the study involve ratios or natural logarithms, only those firms reporting positive (nonzero) values for data used in the construction of those variables were included.[22] The imposition of these criteria resulted in a sample of 277 firms; 136 are organized as stock companies and 141 as mutuals. Within the stock organizational category, 78 of the firms and/or their parent organizations were privately held during the sample period, whereas 58 were traded on either national or regional exchanges. Of this total, 52.5% or 74 of the mutual firms are group companies, compared to 57.7% or 45 of the private stock firms and 91.4% or 53 of the publicly traded stock organizations. The chi-square test of independence between ownership structure and group affiliation reveals that the difference in percentages between publicly traded stock firms and the other organizational forms is statistically significant; that is, there exists a significant association between ownership structure and group affiliation in the sample.[23]

A two-pass regression procedure was adopted.[24] In the first pass,

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[22] The required variables include earned premiums, net premiums written, policyholders' surplus, admitted assets, the sum of assumed plus ceded reinsurance. Also, information concerning the total investment in the following asset categories is required: long-term government bonds, long-term obligations of government agencies, and other long-term bonds.

[23] This significant association between organizational form and group affiliation makes it especially important to include group affiliation as a control variable in the regression analysis that follows.

[24] A two-stage regression approach, with the second stage explaining the coefficients of the first stage, has a long-standing tradition in empirical finance (e.g., in tests of

the GLS regression described by the following equation was estimated for each of the 277 firms in the sample:

$$r_{ujt} = \alpha_{0j} + \alpha_{1j}(kr_{ft}) + \epsilon_{jt}, \tag{8}$$

where r_{ujt} is the period t underwriting return for firm j,[25] and the term kr_{ft} corresponds to the period t product of the average settlement delay and the annualized weighted average of monthly returns on 1-year Treasury bills in the year surrounding time t.[26]

In the absence of capacity constraints, the α_{1j} coefficients in the first pass should not differ significantly from negative unity. With differences in duration and differences in access to capital and reinsurance markets, however, there should be cross-sectional variation in the α_{1j} coefficients as predicted by equation (5). Accordingly, the parameter estimates α_{1j} were then used in a second-pass OLS regression in order to test for cross-sectional differences in the responsiveness of α_{1j} to a number of firm-specific variables. The second-pass equation was specified in the following manner:

$$\alpha_{1j} = \beta_{0j} + \sum_{i=1}^{n} \beta_{ij} X_{ij} + \mu_j, \tag{9}$$

where

X_{1j} = SIZE$_j$ = natural logarithm of firm j's size, measured in terms of admitted assets;
X_{2j} = QDUR$_j$ = mean value of equity duration for firm j during the period 1980–86;
X_{3j} = REINS$_j$ = the slope coefficient determined from the OLS regression of the reinsurance variable against returns on 1-year Treasury bills;
X_{4j} = PUBLIC$_j$ = 1 if firm j or its parent is a publicly traded stock corporation, 0 otherwise;
X_{5j} = PRIVATE$_j$ = 1 if firm j or its parent is a privately held stock corporation, 0 otherwise;
X_{6j} = GROUP$_j$ = 1 if firm j is an insurance group, 0 otherwise;
X_{7j} = GROUPRE$_j$ = the product of GROUP$_j$ and REINS$_j$.

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asset pricing models). Alternatively, a one-stage model could have been estimated that included interaction effects. We chose the two-stage approach primarily because its results are more easily and intuitively interpreted. Our primary interest is in determining how firm-specific characteristics influence the interest rate sensitivity of underwriting returns, and the two-stage approach provides the most direct answer to this question.

[25] The rate of return on underwriting was calculated by employing the standard method of subtracting the period t combined ratio for firm j from "1."

[26] In addition to the model described in eq. (8), another model in which the period t return on a 1-year Treasury bill was substituted for the weighted average return was also estimated. Since the parameter estimates are very similar for both alternative model specifications, only the results for the model described in eq. (8) are reported here.

An explanation of the rationale behind how the variables were constructed is in order. The QDUR variable was determined by a two-step procedure. First, asset and liability durations were calculated annually for each firm during the period 1981–86.[27] Once these values were determined, they were combined in a linear fashion with contemporaneous values of the asset/equity ratio in the manner indicated in equation (4).[28] Since we wish to test for the effect of access to reinsurance, we measured the sensitivity of net ceding transactions to changes in interest rates by regressing the reinsurance variable against returns on 1-year Treasury bills.[29] We define our reinsurance access variable as the slope coefficient taken from this regression and use it in the cross section analysis. The control variables are GROUP and GROUPRE.[30]

C. Cross-Sectional Analysis: Results

Our model predicts that those firms for which changes in capital structure are most costly will exhibit greatest difficulty in adjusting to equilibrium prices following changes in interest rates. Firms with high equity duration and more costly access to reinsurance and capital markets will show the greatest frictional disturbances in their insurance prices following a change in interest rates.

The most direct test of our model is that for equity duration, QDUR. Consider first firms that hedge asset and liability risk through duration

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[27] The calculations of asset and liability duration were based on detailed regulatory filings. Equities were assumed to have the same duration as the average of the Standard and Poor's 500 portfolio, whereas bond durations are based on the average life. In the case of bond durations, adjustments are made in order to account for differences in durations of government, municipal, and corporate bonds. Finally, the duration of liabilities was calculated in two ways. The duration of Schedule P lines was calculated by implementing the modified Taylor separation procedure described in Staking and Babbel (1990), while the short-tail lines are based on industry duration factors computed by Babbel, Klock, and Polachek (1988). The year 1981 was chosen as the initial year because the data requirements of the algorithms used in the calculation of the liability duration, combined with the lack of availability of Schedule P data before 1976, make it the first year for which such a calculation is possible. Since duration numbers are generally fairly stable for most firms over time, little is gained from extending the calculations much beyond 5 years. Consequently, 1986 was chosen as the terminal year for these calculations.

[28] Ideally, we would prefer to calculate the leverage ratio in eq. (4) with the market values of assets and surplus. Since market values were unavailable, book values were used.

[29] The dependent variable in this regression is determined by calculating the ratio of ceded reinsurance into the sum of ceded plus assumed. By construction, it is designed to assume a minimum value of zero and a maximum of unity. If a value of 0 (1) is realized, all reinsurance activity is due to assumption (ceding).

[30] An interaction effect between the GROUP and REINS is incorporated since, before 1988, the annual statement forms on which the Best tapes are based did not discriminate between reinsurance transactions with affiliated vs. unaffiliated firms. Since unaffiliated firms can only reinsure with other unaffiliated firms, one would expect that reinsurance data for groups are likely to differ systematically from the reinsurance data for unaffiliated firms.

TABLE 1 **Results of Cross-Sectional Analysis of Interest Rate Sensitivity of Underwriting Returns**

	Regression 1		Regression 2	
Variable	Coefficient	P^*	Coefficient	P^*
INTERCEPT	−4.6792	.0001	−3.8091	.0001
QDUR	.0154	.0589	. . .	. . .
ADUR	. . .	. . .	−.2007	.0006
LDUR	. . .	. . .	.5882	.0001
PUBLIC	−.0028	.4930	.0647	.3429
PRIVATE	−.6740	.0001	−.7870	.0001
SIZE	.1386	.0001	.0492	.0096
REINS	.0782	.0841	.0606	.1398
GROUP	1.1712	.0001	1.2795	.0001
GROUPRE	.0175	.4031	.0316	.3266
Adjusted R^2	.0590		.0845	

* One-tailed test.

management. For such firms, interest rate changes would leave the capital structure largely unaffected. Firms should be able to adjust insurance prices to interest rate changes as predicted by equation (1). For such firms, the interest sensitivity coefficient from equation (8) should be close to negative unity. Nearly all of the firms in our sample, however, have positive equity durations. Our model predicts that the interest sensitivity should be negatively related to equity duration, and this is confirmed in regression 1 of table 1 at the 6% level. This suggests that duration mismatched firms do indeed have greater difficulty responding to interest rate changes. A problem with this result is that the equity duration may be subject to measurement error since QDUR is assembled from asset and liability durations using a leverage term (see eq. [4]) that is measured using statutory accounting numbers. Using market values also would be problematic since these are sensitive to interest rate changes. For this reason, we performed a second regression using separate left-hand-side variables for asset duration, ADUR, and liability duration, LDUR, for which the predicted signs are negative and positive, respectively. Regression 2 of table 1 confirms these predictions at high confidence levels.

While duration measures translate interest rate changes into equity shocks, other variables are used to reveal the costs to insurers from absorbing these shocks. For example, the cost of a given equity shock is higher for firms that face high costs in accessing capital or reinsurance markets. Thus we need variables that proxy for these differential transaction costs. The cost of raising new capital (access to capital markets) is likely to differ between stock companies and mutuals. Mutuals have no direct access to new issue markets and can replace capital only by retaining earnings (although borrowing is technically possible, it is highly restricted by insurance regulation). We also distinguish between public and private companies, with the former being assumed to have lower costs of access to capital and reinsurance markets. These three organizational forms are represented by the dummy variables PUBLIC and PRIVATE. By construction, the coefficients associated with PUBLIC and PRIVATE reflect the extent to which the intercept differs when a publicly traded or privately held stock company, rather than a mutual company, is considered. We also include SIZE as a capital access variable, reasoning that the costs of capital access should be smaller for large firms.[31] The signs for PUBLIC and SIZE should be positive. SIZE is positive and significant in both regressions 1 and 2, but PUBLIC does not differ significantly from zero and has the predicted positive sign only in regression 2. The predicted sign for PRIVATE is ambiguous, since we cannot provide an expected ranking of the transaction costs of privately held stock companies and mutuals. The results show the coefficient for PRIVATE to be negative and statistically significant. The reinsurance access variable REINS described in the previous section is used since reinsurance provides a capital substitute. The predicted value is positive, and, while this sign is confirmed, the results are not significant.

Overall, the results of the cross-sectional tests support the model. The most direct predictions of our model relate to the effects of a duration mismatch, and these predictions receive empirical confirmation. The results on the capital access variables and the capital substitute variables are generally supportive, being mostly either of the correct sign and significant or insignificant.

IV. Conclusion

Changes in interest rates cause changes in the level of underwriting profits required for market clearing. If the insurer operates with an asset/liability duration mismatch, however, the same interest rate changes also affect the value of the insurer's equity and disturb its capital structure. If it is costly to change capital structure (by new issues, repurchases, etc.), one would expect that firms would attempt to reestablish a more appropriate leverage by adjusting the quantity of insurance supplied. Time-series analysis confirms that cycles do seem to be dampened from the equilibrium path, which points to the presence of capacity constraints. Asymmetric responses to rising and falling interest rates provide further support for the presence of capacity

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[31] The empirical evidence on raising external capital suggests that larger firms are more likely to make larger new issues for which issue costs are lower (see Smith 1986). Moreover, access to information on large firms might be lower, thereby reducing costs of information asymmetry.

constraints. The cross-sectional analysis reveals that price disturbances are more pronounced in those firms for which leverage adjustments are most costly. Specifically, firms with more costly access to new equity, or with less flexible access to reinsurance markets, show more evidence of frictions in responding to changing capital market changes. These results support the general class of capacity constrained models of insurance cycles.

Our results bring up some interesting questions about the issue of the optimal maturity structure of insurer assets and liabilities. It is interesting that we find that most insurers do not manage their assets and liabilities in a manner that minimizes the interest rate sensitivity of their equity. In most cases, assets have higher durations than liabilities.[32] One possible explanation is the agency argument, which states that that shareholders may have incentives to mismatch since, by increasing risk, they extract wealth from policyholders by increasing the value of their "option to default." This explanation is valid so long as insurance prices do not fully anticipate changes in default risk.[33] Furthermore, there may be some tax incentives to mismatch (see Cummins and Grace (1994). Still, the question of optimal maturity structure for insurer assets and liabilities remains a largely unresolved issue.

The results carry some policy implications. During the past decade, the insurance industry has been subjected to a number of regulatory initiatives at both state and federal levels. These initiatives include the imposition of direct price regulation (e.g., Proposition 103 in California),[34] requirements that insurers write policies even when it is not profitable to do so,[35] and efforts in Congress to substitute federal for state regulation. Part of the impetus behind this regulatory activity is an apparent desire to stabilize insurance prices in the face of changing interest rates. On balance, our analysis suggests that, if anything, prices are *underresponsive* to interest rate changes. Consequently, attempts at direct stabilization would simply lead to more extensive use of rationing to clear markets. The so-called insurance availability problem, discussed so often in the press, would simply be aggravated.

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[32] In fact, in absolute dollar terms, the property-liability insurance industry holds more long-term (with maturities exceeding 10 years) tax-exempt debt than any other investor group in the economy (see Walker 1991). Cummins and Grace (1994) attribute this industry's preference for long-term tax-exempt securities largely to tax incentives.

[33] The degree of sensitivity of insurance prices to changes in default risk are likely to be influenced by the existence of state insurance guaranty funds.

[34] Proposition 103 was a voter referendum that passed by a narrow (51%–49%) margin in the November 1988 general election in California. Proposition 103 called for, among other things, the imposition of a system of "prior approval" price regulation in the market for automobile insurance. Prior to Proposition 103, prices were regulated primarily by market forces.

[35] In many states, regulators have threatened to withdraw licenses from insurers that attempt to withdraw from sale of individual lines of insurance.

References

Babbel, D. F.; Klock, D. R.; and Polachek, M. 1988. Assessing the interest rate risk of property and casualty companies. *Insurance Perspectives*. Goldman, Sachs, April.

Babbel, D. F., and Staking, K. B. 1989. The market reward for insurers that practice asset liability management. *Insurance Perspectives*. Goldman, Sachs, November.

Berger, L. A. 1988. A model of the underwriting cycle in the property/liability insurance industry. *Journal of Risk and Insurance* 55 (June): 298–306.

Biger, N., and Kahane, Y. 1978. Risk considerations in insurance ratemaking. *Journal of Risk and Insurance* 45 (March): 121–32.

Brockett, P. L., and Witt, R. C. 1982. The underwriting risk and return paradox revisited. *Journal of Risk and Insurance* 49 (December): 621–27.

Cummins, J. D. 1988. Risk-based premiums for insurance guaranty funds. *Journal of Finance* 43 (September): 823–39.

Cummins, J. D., and Danzon, P. 1991. Price shocks and capital flows in liability insurance. In J. D. Cummins, S. E. Harrington, and R. W. Klein (eds.), *Cycles and Crises in Property/Casualty Insurance: Causes and Implications for Public Policy*. Kansas City: National Association of Insurance Commissioners.

Cummins, J. D., and Grace, E. 1994. Tax management and investment strategies of property-liability insurers. *Journal of Banking and Finance* 18 (January): 43–72.

Cummins, J. D., and Harrington, S. E. 1985. Property-liability insurance rate regulation: Estimation of underwriting betas. *Journal of Risk and Insurance* 52 (March): 16–43.

Cummins, J. D., and Outreville, F. 1987. An international analysis of underwriting cycles in property-liability insurance. *Journal of Risk and Insurance* 53 (June): 246–62.

D'Arcy, S. P., and Doherty, N. A. 1988. *The Financial Theory of Pricing Property-Liability Insurance Contracts*. Huebner Foundation Monograph no. 15. Philadelphia: University of Pennsylvania, Wharton School.

D'Arcy, S. P., and Doherty, N. A. 1990. Adverse selection, private information, and low-balling in insurance markets. *Journal of Business* 63 (April): 145–64.

Derrig, R. A. 1989. Solvency levels and risk loadings appropriate for fully guaranteed insurance contracts. In R. A. Derrig and J. D. Cummins (eds.), *Financial Models of Insurance Solvency*. Boston: Kluwer-Nijhof.

Doherty, N. A., and Garven, J. R. 1986. Price regulation in property-liability insurance: A contingent claims approach. *Journal of Finance* 41 (December): 1031–50.

Doherty, N. A., and Garven, J. R. 1991. Capacity and the cyclicality of insurance markets. In J. D. Cummins, S. E. Harrington, and R. W. Klein (eds.), *Cycles and Crises in Property/Casualty Insurance: Causes and Implications for Public Policy*. Kansas City, Mo.: National Association of Insurance Commissioners.

Doherty, N. A., and Kang, H. B. 1988. Interest rates and insurance price cycles. *Journal of Banking and Finance* 12 (June): 199–214.

Doherty, N. A., and Posey, L. 1993. Asymmetric information and availability crises in insurance markets: Theory and evidence. Working paper. Philadelphia: University of Pennsylvania.

Doherty, N. A., and Schlesinger, H. 1990. Rational insurance purchasing: Consideration of contract non-performance. *Quarterly Journal of Economics* 105 (February): 243–53.

Fairley, W. B. 1979. Investment income and profit margins in property-liability insurance. *Bell Journal of Economics* 10 (Spring): 192–210.

Flannery, M. J., and James, C. M. 1984. The effect of interest rate changes on the common stock returns of financial institutions. *Journal of Finance* 39 (December): 1141–53.

Grøn, A. 1989. Capacity constraints and cycles in property-casualty insurance markets. Working paper. Cambridge: Massachusetts Institute of Technology.

Grøn, A. 1994. Capacity constraints and cycles in property-casualty insurance markets. *Rand Journal of Economics* 25 (Spring): 110–27.

Grace, M. F., and Hotchkiss, J. L. 1995. External impacts on the property-liability insurance cycle. *Journal of Risk and Insurance,* in press.

Harrington, S. 1988. Prices and profits in liability insurance markets. In R. E. Litan and C. Winston (eds.), *Liability: Perspectives and Policy*. Washington, D.C.: Brookings Institution.

Hill, R. D. 1979. Profit regulation in property liability insurance. *Bell Journal of Economics* 10 (Spring): 172–91.

Hill, R. D., and Modigliani, F. 1987. The Massachusetts model of profit regulation in non–life insurance. In J. D. Cummins and S. E. Harrington (eds.), *Fair Rate of Return in Property-Liability Insurance*. Boston: Kluwer-Nijhof.

Kraus, A., and Ross, S. A. 1982. The determination of fair profits for the property-liability insurance firm. *Journal of Finance* 37 (September): 1015–28.

Myers, S. C., and Cohn, R. 1987. A discounted cash flow approach to property-liability rate regulation. In J. D. Cummins and S. E. Harrington (eds.), *Fair Rate of Return in Property-Liability Insurance*. Boston: Kluwer-Nijhof.

Myers, S. C., and Majluf, N. S. 1984. Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics* 13 (June): 187–221.

Rothschild, M., and Stiglitz, J. E. 1976. Equilibrium in competitive insurance markets: An essay on the economics of imperfect information. *Quarterly Journal of Economics* 90 (November): 629–49.

Smith, M. E. 1980. The underwriting cycle in property and casualty insurance. Ph.D. dissertation, University of Utah, Department of Finances.

Staking, K. B., and Babbel, D. F. 1990. Interest rate sensitivity and the value of surplus: Duration mismatch in the property-liability insurance industry. Working paper. Philadelphia: University of Pennsylvania.

Tennyson, S. 1990. Supply dynamics and underwriting cycles in property-liability insurance. Ph.D. dissertation, Northwestern University, Department of Economics.

Venezian, E. 1985. Ratemaking methods and profit cycles in property and liability insurance. *Journal of Risk and Insurance* 52:477–500.

Walker, R. A. 1991. Do Taxes Matter? The Case of the Property-Casualty Insurance Industry. Ph.D. dissertation, University of Texas at Austin, Department of Accounting.

Watts, R. L., and Zimmerman, J. L. 1986. *Positive Accounting Theory*. Englewood Cliffs, N.J.: Prentice-Hall.

Winter, R. A. 1988. The liability crisis and the dynamics of competitive insurance markets. *Yale Journal on Regulation* 5 (Summer): 455–99.

Winter, R. A. 1991. The liability insurance market. *Journal of Economic Perspectives* 5 (Summer): 115–36.

Winter, R. A. 1995. The dynamics of competitive insurance markets. *Journal of Financial Intermediation,* in press.