20 Volatility and Underwriting Cycles

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Abstract

This paper describes and illustrates the main ideas and findings of research on the volatility and cyclical behavior of insurance prices relative to those predicted by a perfectly competitive market in long-run equilibrium. After presenting evidence that insurance market prices indeed follow a second order autoregressive process, we examine several lines of research that have tried to explain the cyclical behavior of insurance prices. Particular emphasis is given to the theoretical developments of and empirical results supporting capital shock models, which primarily explain periods of high insurance prices. We then summarize the idea that moral hazard and/or winners curse effects can explain periods of low insurance prices. Finally, the potential effects of regulation on insurance price volatility are summarized.

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20.1 INTRODUCTION

Markets for many types of property-liability insurance have exhibited soft market periods, where prices and profitability are stable or falling and coverage is readily available to consumers, and subsequent hard market periods, where prices and profits increase abruptly and less coverage is available. The mid 1980s liability insurance crisis was the most recent severe hard market. The dramatic increases in business liability insurance premiums and reductions in the supply of coverage for some sectors received enormous attention in the media and by policymakers. The mid-1980s experience also spawned extensive research on this hard market episode and the general causes of fluctuations of price and availability of coverage in insurance markets. Subsequent large catastrophe losses in the late 1980s and early 1990s has fueled

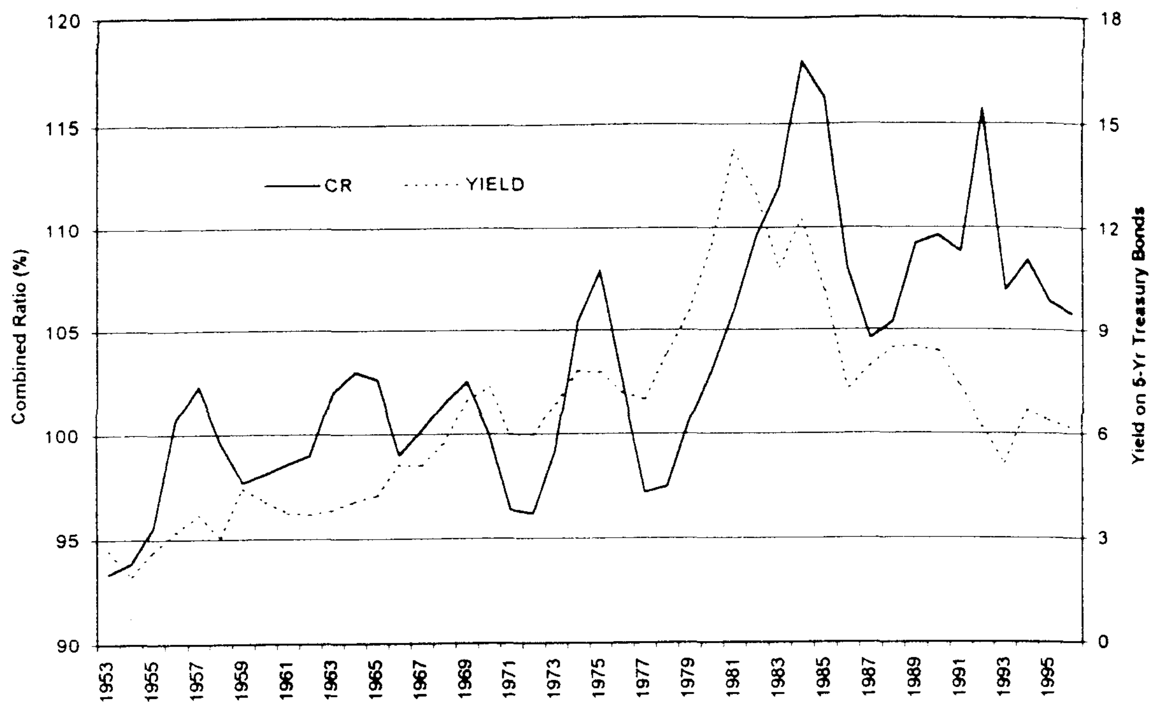

Figure 1 US Combined Ratios and 5-Year Treasury Yields: 1953–96

additional interest and research on short run dynamics of reinsurance and primary market pricing following large losses.

Conventional wisdom among many practitioners and other observers is that soft and hard markets occur in a regular cycle, commonly known as the underwriting cycle. Casual examination of aggregate US underwriting profitability over time, as measured by the combined ratio (see Figure 1), and of aggregate US premiums in relation to gross domestic product (a proxy for aggregate demand for insurance, see Figure 2) suggests material volatility with a cyclical pattern.

This paper introduces the literature on underwriting cycles and volatility in insurance prices and profits.[1] Our purpose is to describe and illustrate the main ideas and findings of research concerning the extent and causes of volatility and cycles. While most empirical research in this area focuses on the behavior of insurance prices, the underwriting cycle lore also relates to the quantity of coverage that is offered by insurers. For example, in hard market periods, coverage may even be rationed for some types of insurance. Due to data availability problems, however, predictions about quantity adjustments generally are not tested. Consistent with the literature, our review focuses on pricing issues with appropriate mention of the predictions of certain models with respect to the quantity of coverage.

[1] See Harrington and Danzon (2000) in this volume for additional discussion of the liability insurance crisis.

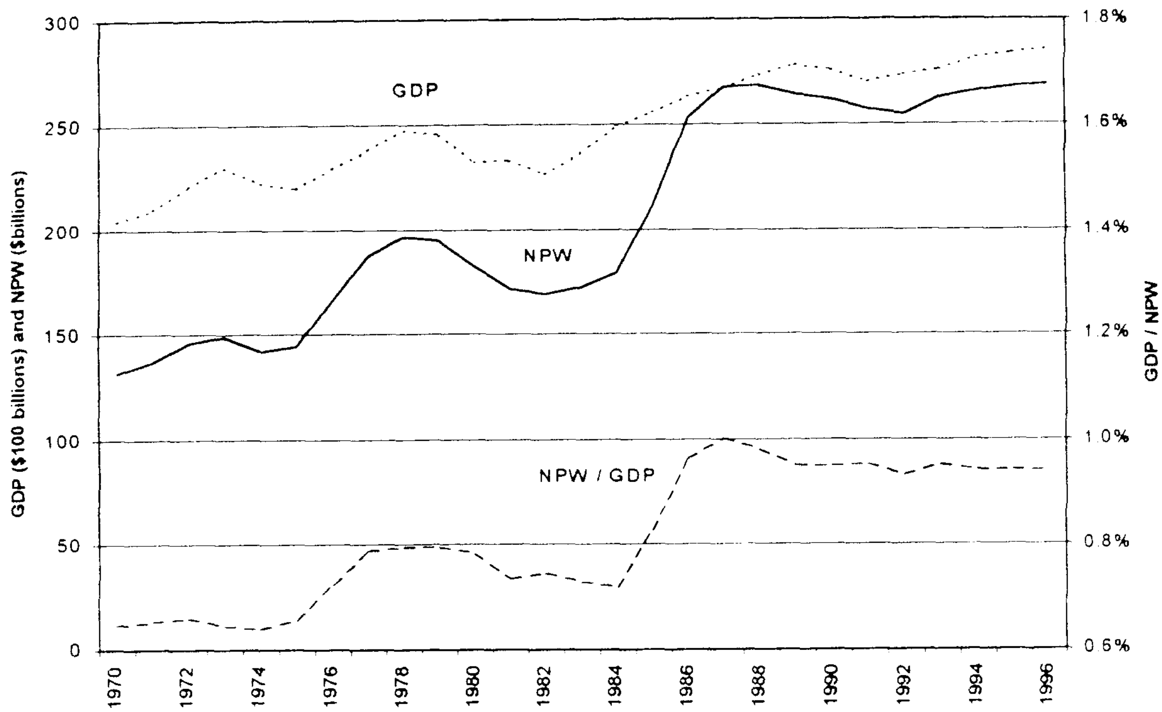

Figure 2 US Net Premiums Written and Gross Domestic Product: 1970–96

Section 20.2 provides an overview of the major determinants of insurance prices in a perfectly competitive insurance market in long-run equilibrium. Section 20.3 defines unexplained and possibly cyclical variation in prices and underwriting results compared to this benchmark. We then provide a synopsis of the evidence from simple time series models that indicates that underwriting results follow a second-order autoregressive process. We illustrate these findings using data on aggregate underwriting profits for US property-liability insurance market during the period 1955–96. We also briefly discuss several comparatively recent studies that have investigated whether underwriting results have unit roots and are cointegrated with a number of macroeconomic factors.

The growing body of theoretical and empirical work on the effects of shocks to capital on the supply of insurance is introduced in Section 20.4. Section 20.5 provides an overview of research that focuses on the extent and causes of price reductions during soft markets. Section 20.6 considers regulatory influences on volatility and cycles. Section 20.7 concludes.

20.2 THE PERFECT MARKETS MODEL

Standard financial theory predicts that in long-run equilibrium competitively determined insurance premiums, commonly known as *fair premiums*, will equal risk-adjusted discounted values of expected cash outflows for claims, sales expenses, income taxes, and any other costs, including the tax and agency costs of capital (e.g., Myers and Cohn, 1986; or, for some bells and whistles, see Doherty and Garven, 1986). We use the term *perfect markets model* to refer to this model, with the additional assumptions (see Cummins and Outreville, 1987, and Harrington and Danzon, 1994) that (1) expectations are rational (optimal) forecasts conditional on information available when policies are sold, and that (2) insurer capital is sufficient to produce a negligible level of insolvency risk.

Given this framework, volatility in insurance premiums, prices, and profit rates can be viewed as having two components: (1) volatility that can be explained by the perfect markets model, i.e., by changes in fair premiums, and (2) volatility that cannot be explained by changes in fair premiums. The perfect markets model also implies that the quantity of coverage sold will vary inversely with changes in fair premiums and directly with the demand for coverage, and that quantity will not be rationed.

To make these notions more concrete, consider a highly stylized representation of the fair premium for a given policy or group of policies at the beginning of period t:

$$P_t^f = \delta_t L_t^f + \alpha_t P_t^f + \pi_t P_t^f. \tag{1}$$

P_t^f is the fair premium. L_t^f is the rational (optimal) forecast (i.e., conditional expectation given all available information) of nominal (undiscounted) claim costs (including loss adjustment expenses) for insured events during the coverage period. The parameter δ_t is the risk-adjusted discounted value of \$1 of L_t^f, which depends on riskless spot interest rates at time t for periods over which cash flows from the policy occur and any risk premia for systematic risk associated with claim costs. The parameter α_t is the known loading for underwriting and administrative expenses paid at the beginning of the period, and π_t is the fair pre-tax profit margin that is just sufficient to compensate shareholders for tax and agency costs of capital (and expected taxes on any underwriting profits), again assuming that the amount of capital invested is sufficient to produce a negligible probability of default by the insurer.[2]

Solving (1) for P_t^f gives:

$$P_t^f = \delta_t (1 - \alpha_t - \pi_t)^{-1} L_t^f \tag{2}$$

The rational forecasts of the loss ratio (L_t^f/P_t^f) and combined ratio (loss ratio plus underwriting expense ratio) at the beginning of period t are therefore:

[2] Cummins and Phillips (2000) provides detailed discussion of insurance pricing models elsewhere in this volume.

$$LR_t^f = \delta_t^{-1}(1 - \alpha_t - \pi_t) \text{ and} \tag{3}$$

$$CR_t^f = \delta_t^{-1}(1 - \alpha_t - \pi_t) + \alpha_t. \tag{4}$$

Borrowing terminology from the literature on financial price volatility, expressions (2)–(4) indicate that fair premiums, expected loss ratios, and expected combined ratios vary over time in relation to the fundamental determinants of prices. These *fundamentals* include predicted claim costs and underwriting expenses, riskless interest rates, any systematic risk of claim costs and associated market risk premia, and the tax and agency costs of holding capital to bond an insurer's promise to pay claims.[3] Expense and profit loadings and predicted claims payout patterns tend to vary slowly over time, and systematic (i.e., market) claim risk may be negligible for most types of insurance (see Cummins and Harrington, 1985). As a result, short-run variation in fair premiums will be caused largely by changes in predicted claim costs and interest rates. Correspondingly, this model predicts that changes in interest rates will be the primary cause of short-run variation in underwriting profit margins. Over longer periods, changes in capital structure that alter π and changes in technology that alter α will play a more material role according to this model.

Not surprisingly, there is abundant evidence that changes in claim costs, which should be highly correlated with insurer forecasts when policies are priced, explain much of the time series variation in premiums.[4] Examples include studies of premium growth in automobile insurance (e.g., Cummins and Tennyson, 1992), medical malpractice insurance (Danzon, 1985), and workers' compensation insurance (e.g., Danzon and Harrington, 1998).[5] Also consistent with the perfect markets model, numerous studies have documented the predicted inverse relationship between interest rates and loss ratios or combined ratios (Doherty and Kang, 1988; Fields and

[3] Capital shock models (discussed in Section 20.4) suggest that capital costs per unit might vary inversely with the total level of capital. Also, models incorporating default risk suggest that, all else equal, premiums will vary directly with the total level of insurer capital. Sommer (1996) presents evidence that prices vary across insurers in relation to insolvency risk, which of course depends on the amount of capital held. Choi and Thistle (1997), however, find no long-run relationship between aggregate underwriting profit margins and the ratio of capital to assets. Also see Phillips, Cummins, and Allen (1998).

[4] Of course, it also is well known that differences in predicted claim costs across regions and risk classes explains much of the cross-sectional variability of premium rates within a given time period (see e.g., Harrington and Niehaus, 1998).

[5] Evidence indicates that a material proportion of the growth in premiums and availability problems in the 1980s was caused by growth in claim cost forecasts and uncertainty of future liability claim costs rather than by cyclical influences (Tort Policy Working Group, 1986, and Clarke, et al. 1988; Harrington, 1988; Harrington and Litan, 1988). Basic theory and numerous studies argue that increased uncertainty would be expected to lead to increases in prices needed to cover expected future costs including the cost of capital (e.g., Danzon, 1984; Doherty and Garven, 1986, Clarke, et al., 1988; and Winter, 1988). Cummins and McDonald (1991) provide evidence of increased variance in liability insurance claim cost distributions during the early 1980s. Other research argues that increased uncertainty is likely to have increased adverse selection and that the introduction of claims-made coverage and the exclusion of pollution claims in basic liability coverage were efficient methods of separating low risk and high risk buyers (Priest, 1987; also see Trebilcock, 1987). See Harrington and Danzon (2000) in this volume for further discussion.

Venezian, 1989; Smith, 1989; Haley, 1993; Grace and Hotchkiss, 1995; Choi and Thistle, 1997; also see Harrington, 1988, and Harrington and Litan, 1988). Evidence also suggests that underwriting results vary in relation to changes in the estimated market price of risk, as is predicted if claim costs load on priced risk factors in the economy (see Cagle, 1992).[6] In addition, premium levels appear to vary predictably in relation to changes in income tax treatment of insurers (see Bradford and Logue, 1996).

To be sure, even skeptics concede that fundamentals explain at least part of the variation in premiums; the key question is how much. Before turning to a discussion of evidence that is more difficult to reconcile with the model, we first provide a simple framework for understanding this evidence.

20.3 UNEXPLAINED / PREDICTABLE VARIATION IN UNDERWRITING RESULTS

Empirical Framework

Given the perfect markets framework, unexplained premium volatility can be represented as variation of actual premiums around fair premiums. Letting u_t denote any component in premiums that cannot be explained by fundamentals in period t, the actual premium can be written as:

$$P_t = P_t^f + u_t, \tag{5}$$

where, as before, P_t^f is the rational forecast of costs (see equation 2). The perfect markets model implies that u_t should be serially uncorrelated and uncorrelated with any information available at the beginning of period t, including P_t^f and past profitability. The variance of u also should be comparatively small. Under these conditions:

$$\text{Var}(P_t) \cong \text{Var}(P_t^f) \tag{6}$$

The hypothesis that variation in premiums is fully explained by variation in fair premiums is surely false, given real world frictions. The interesting questions are whether premiums deviate materially from levels predicted by this model, and, if so, the causes of the deviations. Depending inter alia on the sign of any non-zero covariance between u_t and current and lagged values of P_t^f and any other prior information, unexplained variation in premiums could either increase or decrease premium volatility.

Measuring and testing for unexplained volatility presents several formidable chal-

[6] Mei and Saunders (1994) provide evidence of predictable variation in risk premia for insurance stocks.

lenges. Perhaps most important, expectations and the "true" fair premium model and its parameters are unobservable to researchers. Like tests of market efficiency in financial markets, tests of the perfect markets model of insurance prices using premium data or data on loss ratios or combined ratios are necessarily tests of a joint hypothesis—that premiums are determined primarily by fundamentals and that the assumed model of fair premiums is correct.

Because data on average premiums per exposure generally are not available to researchers, most empirical analyses of volatility in insurance markets use data on loss ratios or combined ratios to control for scale effects and abstract in part from the effects of changes in claim cost forecasts over time. These underwriting profit measures reflect realized claim costs that are reported by insurers, specifically, updated forecasts of incurred losses as of the time those losses are reported. Most studies have necessarily relied on "calendar-year" data in order to obtain enough time series observations for meaningful analysis. Calendar-year losses reflect loss forecasts for accidents during the given year and revisions in loss forecasts for prior years' accidents.

To illustrate the implications of using reported losses (see Cummins and Outreville, 1987, and below for further discussion), the reported combined ratio (CR^r) can be written as the combined ratio predicted by the perfect market model (CR^f) plus two error terms:

$$CR_t^r = CR_t^f + \varepsilon_t + \phi_t, \tag{6}$$

where

$$\varepsilon_t = \frac{L_t^r - L_t^f}{P_t} \quad \text{and} \quad \phi_t = CR_t^m - CR_t^f.$$

The first error, ε, is the difference between reported losses and the rational forecast of losses (L_t^f) as a proportion of premiums. The second error, ϕ, is the difference between the expected combined ratio using L_t^f and market-determined parameters, which we denote CR_t^m, and CR_t^f (see equation 4).[7]

The perfect markets models predicts that ϕ_t is uncorrelated with prior information and that Var(ϕ) is comparatively small. Note that large variation in the rational loss forecast error, ε_t, clearly will produce large variation in reported combined ratios—even if the perfect market model holds. In addition, serial correlation between *reported* combined ratios (or loss ratios) and any other prior information could reflect accounting effects and reporting bias, such as managerial smoothing of reported losses (see Cummins and Outreville, 1987; also see Weiss, 1985, and Petroni, 1992). Serial

[7] For example, market prices could cause π (conditional on L_t^f) to differ from the value implied by the perfect markets model, which would cause CR_t^m to differ from CR_t^f.

correlation in reported underwriting profit measures also might reflect adaptive but rational updating of loss forecasts, rather than unexplained variation in premiums.

Time Series Evidence of Second-Order Autoregression in Underwriting Results

As noted in the introduction, casual observation suggests that insurance premiums are not readily explained by the perfect markets model (e.g., see Figures 1 and 2). Moreover, numerous studies document empirical regularities in underwriting profit measures that are not easily reconciled with the model's predictions. In particular, like many economic time series, numerous studies document that property-liability insurance underwriting results follow a second-order autoregressive process.[8]

This subsection briefly describes time series studies that for the most part do not attempt to explain the causes of second-order autoregression, in contrast to studies that test the predictions of alternative models, such as the capital shock model (see below). We note, however, that the distinction between these avenues of inquiry is not sharp, given that shock models predict correlation between current and past underwriting results. Following this brief description, we provide illustrative evidence of second-order autoregression in underwriting margins and describe analyses that have considered whether underwriting profit measures have unit roots and are cointegrated with interest rates and macroeconomic factors.

Time series studies of underwriting results, like many analyses of the business cycle and of long-term predictability of returns on financial assets, are inherently limited by the comparatively small number of annual observations. In addition, the types of business sold and regulatory environment in the property-liability insurance industry have changed substantially during the latter half of this century, raising serious questions about the stability of the process generating underwriting profits and the efficacy of extending the time series backwards. While some quarterly data are available since the early 1970s (see Cummins and Harrington, 1985), these data may be of limited value in analyzing long-term predictability (see, for example, the general discussion by Enders, 1995; but also see Grace and Hotchkiss, 1995, who employ quarterly data).

As a result of these problems, many studies of volatility in insurance underwriting results employ fairly crude models and statistical methods, especially studies that pre-date developments in modern time series methods. The focus of time series studies on levels or differences in underwriting profit measures, ignoring possible conditional heteroscedasticity, can be explained at least in part by these problems. The estimation of ARCH and GARCH models with annual data over several decades may be unlikely to provide material insight.[9] When considering the following evidence, it is useful to

[8] Berger (1988) shows that if industry supply depends on surplus and current profits depend on lagged premiums and quantity, then premiums follow a second-order autoregressive process.

[9] Fung, et al. (1998) estimate ARCH/GARCH in mean models of changes in by line premiums for the period 1946–1989.

keep in perspective the date that particular studies were conducted and that weak data limit the potential returns from increased methodological sophistication.

Consistent with traditional conjecture, several studies using data prior to the mid 1980s provide statistical evidence that loss ratios and reported underwriting profit margins (e.g., one minus the combined ratio) exhibit second-order autoregression that implies a cyclical period of about six years (see Venezian, 1985; Cummins and Outreville, 1987; and Doherty and Kang, 1988).[10] Statistical analysis also suggests cyclical underwriting results in a number of other countries (Cummins and Outreville, 1987; Lamm-Tennant and Weiss, 1997; Chen, Wang, and Lee, 1999) and different turning points / cyclical periods for different lines of insurance (Venezian, 1985; Fields and Venezian, 1989; Lamm-Tennant and Weiss, 1997).[11]

Studies also suggest that underwriting results remain cyclical after controlling for the expected effects of changes in interest rates (see Fields and Venezian, 1989, and Smith, 1989; also see Winter, 1991a).[12] These results imply that historical cycles in reported underwriting margins cannot simply be explained by the expected effect of changes in interest rates, i.e., that operating profits including investment income also are cyclical. Cagle (1993) presents some evidence of cyclical variation in underwriting results after controlling for variation in the estimated market price of risk (see, e.g., Ferson and Harvey, 1991).

As suggested above, empirical regularities in reported underwriting results could largely or even exclusively be caused by financial reporting procedures and lags in price changes due to regulation. Cummins and Outreville (1987) provide a lucid discussion of this issue. They show conditions under which accounting and regulatory lags could generate a cycle in underwriting margins without either excessive price-cutting during soft markets or sharp reductions in supply following reductions in surplus.[13] However, like other studies, their empirical analysis of underwriting profits cannot distinguish the extent to which correlation in profit measures over time is due to accounting issues and regulatory lags, as opposed to pricing that materially violates the perfect markets model.

In addition, evidence suggests that underwriting expense ratios (ratios of underwriting expenses to written premiums) have varied cyclically after controlling for trend and changes in interest rates (e.g., Ellis, 1988; Cagle, 1993). Cyclical variation in premiums would imply cyclical variation in expense ratios, provided that some expenses are fixed in the short run. As a result, this evidence suggests that pre-

[10] A few studies (e.g., Doherty and Kang, 1988; Grace and Hotchkiss, 1995) also use spectral analysis.

[11] Higgins and Thistle (1997) provide evidence of structural shifts in underwriting returns. Cassidy, Hardigree, and Hogan (1996) present evidence of second order auto regression in health insurance underwriting results.

[12] Other studies analyze the effect of changes in interest rates on fair premiums for commercial liability insurance during the early and mid-1980s (see Harrington, 1988; also see Harrington and Litan, 1988).

[13] The authors note, however, that regulatory lag and financial reporting procedures are unlikely to explain large price fluctuations in the commercial liability insurance market in the mid-1980s.

dictability in reported underwriting results is not fully explained by accounting and reporting lags.

Analogous to Cummins and Outreville, Doherty and Kang (1988) argue that cyclical patterns in underwriting results reflect slow but presumably rational adjustment of premiums to changes in expected claim costs and interest rates. Their empirical work, however, does not clearly distinguish this hypothesis from the alternative of material deviations from the perfect markets model due, for example, to possible suboptimal forecasting.[14]

Illustrative Evidence

Table 1 presents estimates of second-order autoregressive models of aggregate combined ratios for the U.S. property-liability insurance industry using data for the period 1955–96 and for consecutive (over-lapping) 25-year subperiods during this time. Results are shown for two equations each period. The first equation includes a time trend (TIME); the second includes a time trend and the average yield on 5-year (constant maturity) U.S. Treasury Bonds during the year (YIELD; also see Figure 1).[15]

Like earlier studies, the results generally suggest that combined ratios follow a second-order autoregressive process that is consistent with a cycle. The estimated period of the cycle (see Venezian, 1985) is 6.2 years for 1955–1979 and ranges from 7.1 to 9.6 years for the later and longer subperiods. There is no obvious trend in the estimated cyclical period over time. As predicted by the perfect markets model, the coefficient on YIELD is positive and significant for the last 25-year subperiod (1970–94) and for the 40 and 42-year subperiods. The low t-values for the coefficients on YIELD for the earlier 25-year subperiods could reflect inability of the data to distinguish the effects of YIELD and TIME.[16]

Using data for 1972–96 (the most recent 25-year period with available data), Table 2 presents estimates of second-order autoregressive models of (1) the combined

[14] The causes of lags in adjustment are not explored in this work. Also see Tennyson (1993).

[15] Augmented Dickey-Fuller tests (see Enders, 1995) including intercept and trend generally reject the null hypothesis of a unit root for both the combined ratio and interest rate series (as well as the gross margin and the ratio of net premiums written to GDP, see below), and suggest that the series were trend stationary during these periods. Box-Pierce and Box-Ljung statistics generally indicate that the residuals in the models reported in Tables 1 and 3 are white noise (two lags were included). Qualitatively similar results were obtained using yields on 1-year treasuries. Unit root tests suggested that longer-term bond yields were non-stationary. We included a dummy variable for 1992 in the combined ratio models that included this year to control for the effects of Hurricane Andrew on the loss ratio. The implications are not sensitive to the inclusion of this dummy. We emphasize, however, that our purpose is illustrative. Apart from these and a few other robustness checks, we have not investigated the sensitivity of the results of alternative specifications, such as alternative lag structures and the use of first differences. Also see our discussion below of studies that fail to reject the null hypothesis of a unit root (presumably without including a trend variable in the testing equation) and then consider whether underwriting margins are cointegrated with other variables.

[16] When TIME is omitted, the coefficient on YIELD becomes significant in the earlier subperiods. However, the evidence that the series are trend stationary makes interpretation of the models without a trend problematic. Similar results to those reported are obtained when YIELD is interacted with a proxy for the length of the claims tail (i.e., the "funds generation coefficient," calculated as the predicted value of a linear trend model of the ratio of loss and unearned premium reserves to earned premiums).

Table 1

Estimates of Second-Order Autoregressive Models of Industry Combined Ratio
$CR_t = \beta_0 + \beta_1 CR_{t-1} + \beta_2 CR_{t-2} + \beta_3 TIME_t + \beta_4 YIELD_t + v_t$

Sample	Constant	CR_{t-1}	CR_{t-2}	$TIME_t$	$YIELD_t$	Adj. R^2	Period
1955–79	84.18	0.94	−0.80	0.12		0.71	6.2
	(7.27)	(7.37)	(6.23)	(2.48)			
	83.75	0.94	−0.79	0.11	0.05	0.70	6.2
	(6.50)	(7.12)	(5.58)	(0.69)	(0.09)		
1960–84	39.16	1.30	−0.71	0.17		0.77	9.2
	(2.34)	(6.80)	(3.31)	(2.08)			
	34.55	1.21	−0.58	−0.05	0.58	0.77	9.6
	(2.05)	(6.02)	(2.53)	(0.28)	(1.27)		
1965–89	52.84	1.16	−0.71	0.29		0.82	7.8
	(4.51)	(7.53)	(4.57)	(3.29)			
	46.53	1.09	−0.59	0.19	0.33	0.82	8.1
	(3.46)	(6.35)	(2.97)	(1.44)	(0.96)		
1970–94	59.33	0.86	−0.46	0.29		0.69	7.1
	(3.44)	(4.62)	(2.41)	(2.04)			
	44.78	0.73	−0.26	0.22	0.90	0.79	8.2
	(3.04)	(4.70)	(1.56)	(1.87)	(3.33)		
1955–94	54.19	0.88	−0.44	0.17		0.76	7.4
	(4.53)	(6.28)	(3.11)	(2.78)			
	44.28	0.84	−0.32	0.04	0.54	0.79	8.7
	(3.71)	(6.34)	(2.22)	(0.55)	(2.41)		
1955–96	51.62	0.89	−0.42	0.14		0.75	7.7
	(4.45)	(6.46)	(3.04)	(2.57)			
	44.53	0.84	−0.31	0.05	0.54	0.79	8.7
	(4.02)	(6.50)	(2.32)	(0.72)	(2.77)		

Note: Dependent variable is CR_t = loss ratio (adjusted for dividends) plus expense ratio (in percent). $TIME_t$ = time trend. $YIELD_t$ = average percentage yield on 5-year treasury bonds. Period is estimated period of cycle (in years). Absolute t-ratios in parentheses below coefficient estimates. 1970–94, 1955–94, and 1955–96 sample periods include a dummy variable for 1992 (Hurricane Andrew). Sources: *Best's Aggregates & Averages, Property-Casualty, United States*, 1997 (A.M. Best Company) and Federal Reserve Bank of St. Louis FRED data system.

ratio, (2) the gross underwriting margin, defined as 100 percent minus the percentage underwriting expense ratio, and (3) the ratio of net premiums written to GDP (see also Figure 2). The gross margin measures the margin available in premiums to fund predicted claim, tax, and agency costs, and it will reflect any economic profit (or loss). Because neither the gross margin nor the ratio of net premiums written to GDP reflect reported claim costs, any cycle in or interest rate sensitivity of these variables cannot be attributed to bias or lags associated with loss reporting.

Consistent with previous analyses of expense ratios (Cagle, 1993; also see Gron, 1994a), the estimates of the gross margin equations provide strong evidence of second-order autoregression. Results for the ratio of net premiums written to GDP also indicate second-order autoregression. The coefficient on YIELD is not

Table 2

Estimates of Second-Order Autoregressive Models of Industry Combined Ratio, Gross Margin, and Ratio of Net Premiums Written to Gross Domestic Product

$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 TIME_t + \beta_4 YIELD_t + v_t$

Y_t	Constant	Y_{t-1}	Y_{t-2}	$TIME_t$	$YIELD_t$	Adj. R^2	Period
$CR_t = LR_t + ER_t$	50.62	0.88	−0.37	0.12		0.64	8.2
	(3.02)	(4.78)	(1.96)	(0.90)			
	42.39	0.73	−0.23	0.17	0.90	0.76	9.1
	(3.07)	(4.73)	(1.42)	(1.53)	(3.39)		
$GM_t = 100 - ER_t$	35.49	1.25	−0.74	0.29		0.79	8.3
	(4.38)	(8.45)	(4.99)	(2.03)			
	35.47	1.25	−0.74	0.03	0.00	0.78	8.3
	(4.27)	(7.55)	(4.47)	(1.94)	(0.04)		
NPW_t/GDP_t	0.28	1.27	−0.71	0.01		0.94	8.8
	(3.79)	(8.01)	(4.37)	(3.17)			
	0.30	1.23	−0.67	0.01	−0.00	0.94	8.7
	(3.82)	(7.42)	(3.99)	(3.08)	(0.88)		

Note: CR_t = combined ratio (in percent), LR_t = loss ratio (adjusted for dividends), ER_t = expense ratio. GM_t = gross margin, NPW_t/GDP_t = net premiums written divided by gross domestic product (in percent). $TIME_t$ = time trend. $YIELD_t$ = average percentage yield on 5-year treasury bonds. Period is estimated period of cycle (in years). Absolute t-ratios in parentheses below coefficient estimates. Combined ratio model includes a dummy variable for 1992 (Hurricane Andrew). Sources: *Best's Aggregates & Averages, Property-Casualty, United States*, 1997 (A.M. Best Company), Federal Reserve Bank of St. Louis FRED data system, and *Statistical Abstract of the United States*.

significantly negative for either series, in contrast to the prediction of the perfect markets model.[17] These results also contrast with those for the combined ratio, where the coefficient on YIELD is positive and significant as predicted (recall that the combined ratio is an inverse profitability measure). A possible negative relationship between GDP growth and interest rates might obscure the predicted negative effect of interest rates on net premiums written. However, this possibility cannot explain the lack of a relationship between the gross margin and YIELD. Of course, it is not clear which, if any, of these results are spurious (e.g., the strong interest rate sensitivity of the combined ratio, which reflects reported losses, or the lack of interest rate sensitivity of the gross margin and ratio of net premiums written to gross national product, which do not).

What can be made of these results and those of similar studies? Persons predisposed towards the perfect markets model might argue that the generally strong evidence of second-order autoregression and the fragile relationship with interest rates could reflect the small sample period, aggregations bias, structural instability due, for example, to changes in regulation, possible omitted variable or data snooping bias,

[17] When the time trend is omitted, the coefficients are negative but with absolute t-ratios less than one.

and so on. Variation in the estimates for different models and subperiods suggests some fragility in the results. Even so, absent specific details on the causes of any bias, the evidence of second-order autoregression in all three series must be considered anomalous from the perspective of the perfect markets model. This result is by and large consistent with the decades old story about periodic hard and soft markets. Because there is no reason to expect that shocks are predictable, the evidence of *second-order autoregression* in combined ratios or the other variables also is not readily explained by shock models.[18]

Unit Roots and Cointegration

Several comparatively recent time series studies have considered the short and long-run relation between underwriting margins, interest rates, and other macroeconomic variables using cointegration analysis and error correction models. Each of these studies fails to reject the hypothesis of a unit root in underwriting margins and the other series examined, presumably without allowing for trend in the underlying series (as we did). They then assume that the series are difference stationary.[19] Haley (1993) presents evidence that underwriting profit margins and interest rates are negatively related and cointegrated. He also provides evidence of a short-run relation between interest rates and underwriting margins using error correction models.[20] Grace and Hotchkiss (1995) provide evidence of cointegration between quarterly combined ratios and short-term interest rates, the consumer price index, and real GDP. Choi and Thistle (1997) provide evidence that underwriting profit margins are cointegrated with annual Treasury bond yields but not with the ratio of capital to assets.

20.4 CAPITAL SHOCKS AND CAPACITY CONSTRAINTS

Common aspects of capital shock models of underwriting cycles are that (1) industry supply depends on the amount of insurer capital and (2) that industry supply is upward sloping in the short run because the stock of capital is costly to increase due to the costs of raising new capital.[21] These features imply that shocks to capital (e.g., catastrophes or unexpected changes in liability claim costs) affect the price and

[18] Winter's model (see below), for example, implies first-order autoregression, although he suggests that overlapping policy periods might explain second-order autoregression within the context of his model.

[19] Note that our augmented Dickey-Fuller tests that include and intercept and trend (trend was significant) might cast doubt on the assumption that the series have a unit root and are difference stationary. Fung et al. (1998) estimate a VAR model of by line premiums in differences after finding, perhaps not surprisingly, that premiums in levels are non-stationary.

[20] Subsequent analysis of by-line underwriting results (Haley, 1995) suggests cointegration between underwriting margins (weighted by the proportion of total premiums represented by the line each year) and interest rates for some but not all lines.

[21] All of the capital shock models are built on the assumption that external capital is costlier than internal capital. This notion is usually justified using the logic of Myers and Majluf (1984) where managers are better informed than investors and that transaction costs make raising new capital costly.

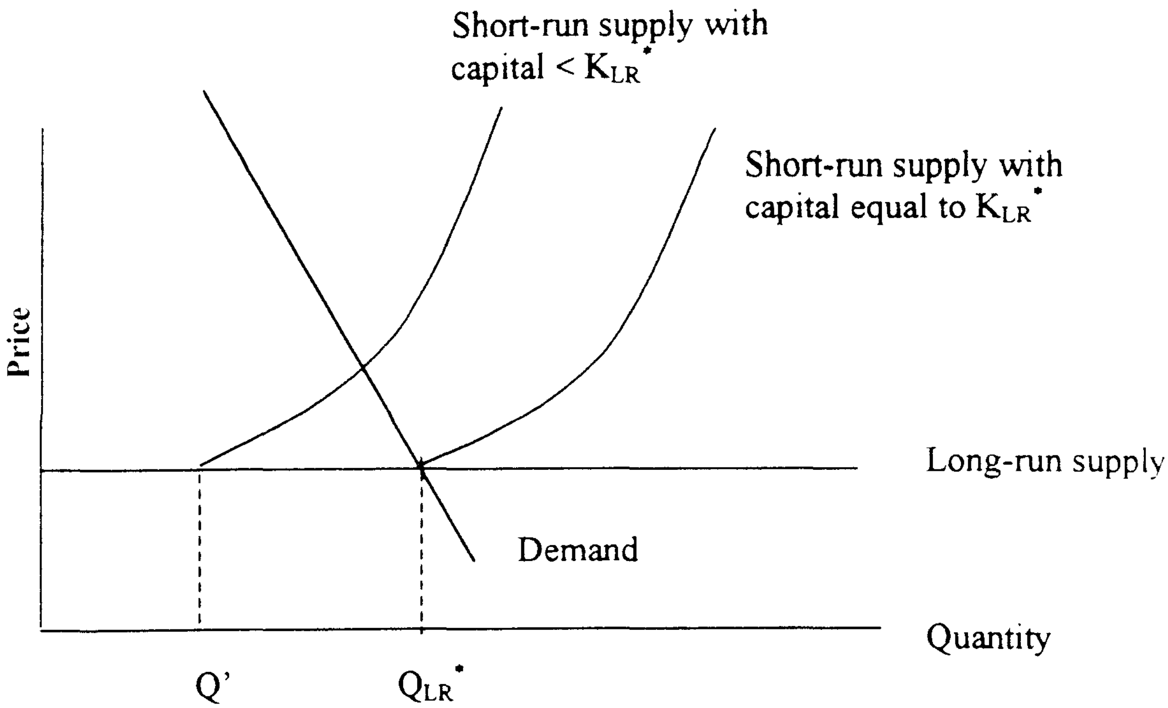

Figure 3 Industry Supply with Capital Shocks

quantity of insurance supplied in the short run.[22] Holding industry demand fixed, a backward shift in supply due to a capital shock causes price to increase and quantity to decrease, which roughly describes the hard phase of the cycle. The soft phase—low prices and high availability—either is not addressed by these models or is explained by periods of excess capital that is not paid out to shareholders because of capital exit costs. After providing an overview of the capital shock models, the empirical evidence is summarized.

The Basic Story

The main theoretical contributions to the literature on the relationship between cycles and insurer capital are Winter (1988, 1991, 1994), Gron (1994a), Cummins and Danzon (1997), Cagle and Harrington (1995), and Doherty and Garven (1995). While the assumptions and specific objectives of these papers differ on some dimensions, the main message is similar: shocks to capital can cause price increases and quantity reductions consistent with a hard market.

To illustrate the basic story, we focus on the determination of three endogenous variables in a competitive market: price, quantity, and insurer capital. Figure 3 illustrates the key ideas for a representative insurer. The horizontal axis measures quantity of coverage as the total value of its expected claim costs. The vertical axis measures the price of coverage as the difference between the premium and the

[22] Similar effects are highlighted in recent macro-finance literature. See, for example, Greenwald and Stiglitz (1993), Bernake and Lown (1991), and Prowse (1997).

expected claim cost per unit of coverage. The price of coverage therefore is the premium loading per dollar of expected claim costs, i.e., the excess amount paid for each dollar of expected claim costs. For simplicity, we ignore the time value of money and administrative costs (underwriting and claims-processing costs). Given the latter assumption, the only input into production of insurance is financial capital.

All capital shock models incorporate the idea that insolvency risk depends on the amount of insurer capital because of uncertainty in claim costs (due to correlation across policyholders) or uncertainty in investment returns (due for example to uncertainty in interest rates). Although not all models consider the issue, we assume that in the long run insurers choose an optimal amount of capital, which equates the marginal costs and benefits of capital.[23] By reducing insolvency risk, additional capital benefits insurers by (1) increasing the demand for coverage by consumers who are averse to insolvency risk (Cummins and Danzon, 1997), and/or (2) reducing the likelihood that insurers lose franchise value (Cagle and Harrington, 1995; also see Pauly, 1984; and Munch and Smallwood, 1982).[24] The costs of insurer capital include double taxation of investment returns on capital and agency costs (Winter, 1994; Cagle and Harrington, 1995).[25] The cost per dollar of capital equals s. The long-run cost of supplying coverage therefore equals the total capital cost per-unit of coverage.[26] Instead of modeling insurer choice of capital based on costs and benefits, some models simply assume that insurer capital must satisfy a regulatory constraint on the probability of bankruptcy (Gron, 1994a and b, and Winter, 1994).

Assuming that the optimal level of capital is a fixed proportion of output, the long-run supply curve is perfectly elastic at the cost per unit of coverage of the optimal long run level of insurer capital (see Figure 3). Exogenously imposing a downward sloping demand curve in Figure 3, the long run equilibrium corresponds to an output level equal to Q^*_{LR}, a level of insurer capital of K^*_{LR}, and a price (premium loading per unit of coverage) equal to the capital costs per unit of coverage, sK^*_{LR}/Q^*_{LR}.

In the capital shock models, short run equilibrium differs from the long run equilibrium because capital adjustment costs cause capital to be a fixed (or at least sticky) factor of production in the short run. Consequently, the short run supply curve is upward sloping. To illustrate, suppose that the representative insurer finds itself with capital equal to the long run optimum, K^*_{LR}, in Figure 3, which corresponds to a long-run output level of Q^*_{LR}, and that capital cannot be adjusted. In order to induce

[23] While the optimal amount of capital per unit of coverage is likely to decline with the number of units of coverage over some range given the greater diversification of claim costs that can be achieved by writing additional coverage, for simplicity, it is common to assume that demand for coverage (at any price) greatly exceeds the point at which such economies of scale are material.

[24] These benefits of holding capital hold over multiple periods, although most models analyze a single period. Thus, to the extent that capital protects insurer franchise value against future shocks or increases consumer demand following future shocks, insurers have greater incentives to hold capital.

[25] As discussed below, the cost of new capital in Cummins and Danzon (1997) is that it bails out old claimants without increasing the premiums paid by these claimants.

[26] The costs of holding capital should be distinguished from the cost of adjusting capital, which are central to short-run analyses of prices and quantities.

the insurer to supply output beyond the long-run equilibrium, the price of coverage would have to increase above the long-run equilibrium price. If insurers increased output and kept price equal to the long-run equilibrium price, then insolvency risk would increase above the optimum level, which would imply a higher cost of selling coverage (e.g., there would be an increased likelihood that the insurer would lose part of its franchise value). Thus, there is an additional cost of increasing output beyond Q^*_{LR}, holding capital fixed at K^*_{LR}. Greater increases beyond Q^*_{LR} imply greater increases in costs. Thus, the short-run supply curve is upward sloping.

The location of the short-run supply curve depends on the amount of insurer capital. If insurer capital were depleted below the long-run equilibrium, then the short run supply curve would be upward sloping starting below Q^*_{LR}. Figure 3 illustrates the case where capital is depleted to the point where the insurer's capital corresponds to a long run equilibrium output level of Q'.

This framework can now be used to motivate how hard markets could develop. A shock to capital in the form of unexpected claim payments on existing policies or a reduction in the value of assets would deplete insurers' capital and shift back the short run supply curve. Holding demand constant, the short run equilibrium price would increase and the short run equilibrium quantity of coverage would decrease, thus producing the hard phase of the cycle.

The higher prices and lower quantities then help to replenish insurer capital and gradually the supply curve shifts back, which lowers price and increases quantity. Insurers also could replenish capital by issuing new debt and equity securities, but raising new capital is costly because of issuance costs and potential underpricing costs. Thus, the short run supply curve is "bounded" by these costs. That is, if price rose sufficiently above the long run equilibrium price, insurers would likely raise new capital, which would shift out the supply curve and cause prices to fall and quantities to increase. Insurers therefore would be more likely to raise new capital following large negative shocks to capital.

Although most models focus on negative shocks to capital (an exception is Doherty and Garven, 1995), it is useful to consider whether positive shocks to capital can explain the soft phase of the underwriting cycle (prices below long run equilibrium prices).[27] Just as there are costs of raising new capital there also are costs of paying out capital (see e.g., Winter, 1994). Insurers can dispose of excess capital by increasing dividends or stock repurchases. Dividend payments, however, can impose tax costs on owners and stock repurchases involve transaction costs. To the extent that these costs induce insurers to hold excess capital, the price of coverage can fall below long run equilibrium levels. Selling policies for less than the long run equilibrium price could be less costly than either paying out the capital or having it less than fully utilized in supporting additional output.

[27] Some authors suggest that capital is gradually restored following negative shocks that cause a hard market, and that prices eventually fall to long-run equilibrium values until another negative capital shock occurs. Accordingly, the soft phase of the underwriting cycle is characterized by prices equal to long-run equilibrium values not by prices below long-run equilibrium values (see e.g., Gron 1994a,b).

In summary, the main predictions from these models are (1) insurance prices are negatively related to insurer capital, (2) the quantity of coverage falls following negative shocks to capital, but coverage is not rationed, and (3) capital infusions (payouts) take place during periods of high (low) insurance prices.

Discussion of Specific Models

Industry Models. Although the insurance cycle is a dynamic phenomenon, most of the capital shock papers employ static models like the one outlined above. The dynamic aspects of the market are then explained by periodic exogenous shocks. An exception is Winter (1994), which models the dynamics of the insurance market in a discrete time equilibrium model. The evolution of insurer capital is explicitly modeled and insurers optimally choose to add or dispose of capital each period, as well as the quantity of coverage to offer.[28] Unlike most other papers, Winter explicitly models the capital adjustment costs (the costs of adding and distributing capital). However, he does not model the optimal level of capital based on the costs and benefits of holding capital. Instead, insurers must hold an amount of costly capital that satisfies the constraint that the probability of insolvency is zero. This constraint, along with the capital adjustment costs, gives rise to an upward sloping short run supply curve. That is, in order for insurers to increase supply beyond the point where existing capital ensures a zero probability of insolvency, price must increase so that the additional revenue from the higher price satisfies the insolvency constraint.

In addition to showing that insurance prices vary inversely with insurer capital and that new additions of capital occur during hard markets, Winter's model also implies that market-to-book ratios are a declining function of insurer capital. Intuitively, as capital becomes scarce, its value within the insurer increases. This suggests that stock market reactions to unexpected losses are less than dollar-for-dollar.[29]

Cagle and Harrington (1995) examine the extent to which the cost of a capital shock may be passed on to consumers in the form of higher prices. In their model,

[28] Relatively little work has been done on dynamic capital structure models in the general finance literature. Fischer, Heinkel, and Zechner (1989) develop a dynamic model of capital structure incorporating adjustment costs. However, unlike the insurance capital shock models, firms' investment decisions are held constant. As in Winter (1994), firms wait to adjust their leverage ratio until it reaches a critical low and high level. They derive and test predictions about how the optimal leverage ratio range varies with parameters measuring bankruptcy cost, tax shields from debt, and risk of the firm's underlying assets. See Mauer and Triantis (1994), Kumar (1998), Goldstein, Ju, and Leland (1998) for other dynamic models of capital structure.

[29] As noted earlier, Winter's model predicts a first order process for prices, not a second order process. He suggests, however, that a higher order process would result from the model if the assumption of single period contracts were replaced with the more realistic assumption of overlapping contracts. Winter (1991b) extends the basic capital shock story by examining the effect of regulation that restricts an insurer's premium to surplus ratio to be below a certain level. This regulatory constraint can further exacerbate the reduction in short-run supply following a capital shock if demand is inelastic. Intuitively, as prices rise in response to the capital shock, inelastic demand implies that premium revenue will increase, which in combination with the reduction in capital causes more insurers to bump up against the regulatory constraint, which in turn causes supply to shift back even more. This story is clever, although there is little evidence that implicit or explicit regulatory constraints in practice are binding for many insurers during hard markets.

insurers choose an optimal level of capital based on the cost of holding capital and the benefits of protecting franchise value. They derive comparative statics for the upper bound effect on price of a shock to capital, assuming that demand is perfectly inelastic and that additional capital cannot be raised. In this best case scenario (for insurers), they show that the entire cost of the shock is not passed on to policyholders. Intuitively, the supply curve is not sufficiently responsive to a decrease in capital to cause prices to increase sufficiently to offset completely the capital shock. The reason for this is that higher prices help to replenish capital, which dampens the effect of the capital shock on supply.

Firm Level Models. The basic idea of the industry level models has also been developed in models of individual insurers. These models do not assume a perfectly competitive market and thus prices can vary across insurers. In addition to the implication that insurance prices rise in response to industry-wide capital shocks, firm level models provide predictions about firm-specific shocks and cross-sectional predictions about industry-wide shocks.

Doherty and Garven (1995) consider the effects of interest rate changes in the context of capital shock models. A change in interest rates can influence capital by changing the value of insurer assets and liabilities. Depending on whether the duration of assets exceeds the duration of liabilities and the sign of the interest rate change, interest rate changes influence the value of an insurer's capital and thus can cause short-run effects similar to those outlined above. In addition, the level of interest rates influences the long-run equilibrium price of coverage—higher interest rates cause the fair premium to decline, all else equal. Thus, they predict that interest rate changes will cause firm-specific capital shocks, as well as alter the long run equilibrium price of insurance. They therefore predict that there will be cross-sectional differences in insurers' price response to interest rate changes, depending on the insurer's exposure to interest rate risk (surplus duration) and its costs of raising capital (mutual versus stock).

Cummins and Danzon (1997) also consider firm specific effects of shocks. They consider an insurer that enters a period with existing liabilities and a stock of capital. The insurer chooses the amount of new capital to raise and the price for new policies. Demand for coverage depends both on price and quality (insolvency risk). The benefit of additional capital is an increase in consumer demand for new policies, but the cost of additional capital is that the old policyholders (existing liabilities) have less insolvency risk, but pay no additional premiums. In essence, capital infusions can bail out old claimants (also see Myers, 1977). Thus, unlike other models that either impose explicit capital adjustment costs (Winter, 1994) or assume capital is fixed in the short run (Gron, 1994a, and Cagle and Harrington, 1995), Cummins and Danzon impose a specific capital market imperfection (or product market imperfection, depending on the semantics you prefer) by assuming contracts with old policyholders cannot be adjusted to reflect changes in default risk.

Another important aspect of Cummins and Danzon's analysis is the explicit modeling of the response of demand to insolvency risk.[30] If price is measured as the premium per policy or per dollar of expected *promised* claim costs, as opposed to per dollar of expected claim costs (where the expectation incorporates default risk), then price would be expected to move inversely with insolvency risk, all else equal. The analogy to risky debt is helpful—as default risk increases, a bond's price would be expected to fall, holding the promised payment constant. Consequently, in response to a capital shock that increased insolvency risk, price could very well fall. In part because of this effect, Cummins and Danzon's model does not provide an unambiguous prediction concerning the effect of a shock on price. Similarly, their model does not provide an unambiguous prediction concerning the response of capital to a negative shock. In their model, insurers face a trade-off with respect to raising additional capital. Additional capital will transfer wealth to old policyholders, but will also increase demand by new policyholders.

Although not specific to insurers, Froot and Stein (1998) present a model that provides some interesting predictions about the effect of capital shocks to insurers. In their model, firms are faced with the possibility of a shock that will deplete internal funds. Due to the costs of raising external capital, the realization of the shock will cause the firm to pass up profitable investment opportunities (also see Froot, Scharfstein, and Stein, 1993). The firm can manage this risk by (1) holding capital ex ante, which is costly due to tax and agency costs, (2) engaging in costly hedging (reinsurance) transactions, and (3) adjusting their exposure through their investment policies. Their model implies that insurer pricing depends on their capital. Consequently, capital shocks should affect pricing across lines of business, regardless of the source of the shock.[31]

Empirical Evidence on Capital Shock Models

The capital shock models have motivated considerable empirical research. The most important prediction of most of these models is that insurance prices are negatively related to insurer capital. As discussed earlier, a problem encountered by empiricists is that the ex ante price of insurance is not observable because expected losses are unobservable. Thus, most studies examining the relation between price and capital use some variant of premiums relative to realized losses as a measure of price.[32] Table 3 summarizes some of the empirical evidence on the capital shock models. In the following pages, we provide some additional detail of selected papers listed in Table 3 to provide an overview of how the capital shock models have been tested.

[30] As noted earlier, Winter (1994) avoids this issue by imposing a zero probability of insolvency constraint, and Gron (1994a) assumes that there is regulatory constraint on the probability of insolvency. Cagle and Harrington (1995) consider demand responses to capital shocks and show that such responses diminish the ability of insurers to recoup losses from price increases following capital shocks.

[31] Also see the model and discussion in Gron and Winton, 1999.

[32] A number of studies (e.g., Shelor, Anderson, and Cross, 1992; Anghazo and Narayanan, 1996) analyze insurer stock price responses to large unexpected claim costs. In principal, analysis of stock returns around

Table 3
Evidence on Capital Shock Models

Study	Data	Main Results
Industry Aggregate Time Series Studies		
Winter (1994)	'48–'88	Difference between premiums and prediction of the present value of future losses is negatively related to insurer capital
Gron (1994a)	'49–'90	Changes in premiums minus underwriting expenses (the "price payment margin" or PPM) are negatively related to lagged capital. Negative capital shocks influence PPM more than positive capital shocks. Capital growth is positively related to contemporaneous PPM.
Niehaus and Terry (1993)	'46–'88	Premiums are related to lagged capital
Choi and Thistle (1997)	'26–'93	Surplus is not a determinant of profits in the short run or long run
Higgins and Thistle (1997)	'34–'93	Underwriting profits follow an AR(1) process when capital is high and AR(2) process when capital is low
Insurer Panel Data		
Cummins and Danzon (1997)	'80–'88	Capital flows are positively related to price changes and loss shocks
Doherty and Garven (1995)	'76–'88	Sensitivity of insurer underwriting returns to interest rates (speed of adjustment) is negatively related to surplus duration (capital shock from the interest rate change)
Guo and Winter (1997)	'90–'95	Ratio of capital to premiums is positively related to past profitability
Aggregate Line-Specific Data		
Froot and O'Connell (1997)	catastrophe reinsurance	Prices increase following capital shocks even for catastrophes and regions not affected by the shock
Yuengert (1991)	Six lines, '84–'89	Prices are positively related to capital and negatively deviations of capital from its average level
Gron (1994b)	Four lines, '52–'86	Underwriting profits are negatively related to capital for auto physical damage, homeowners, auto liability, but not other liability
Froot and O'Connell (1996)	catastrophe reinsurance	Low estimates for the price elasticity of supply
Other Evidence		
Gron and Lucas (1994)	Insurer financing decisions '70–'93	Payout ratios fall following shocks; equity issues increase following shocks, but most additional capital is small relative to size of capital shocks
Gron (1995b)	Agent commissions '55–'85	Commission rates decline during hard markets

Aggregate Time Series Studies. Winter (1994) calculates an "economic loss ratio" for year t as the present value of an estimate of actual future claims arising from policies sold in year t divided by premiums in year t. The economic loss ratio is regressed on the lagged values of insurer capital relative to its previous five-year average and interest rates. Consistent with the prediction of the capital shock models that higher prices (lower expected loss ratios) occur when capital is low, the coefficients on the lagged capital variables are positive and statistically significant in most of his specifications.[33]

Gron (1994a) uses both the difference between premiums and underwriting expenses and the ratio of premiums to underwriting expenses as dependent variables. To control for the present value of claim costs, she includes variables for the expected inflation rate and interest rates. GNP is used to control for demand. Consistent with capital shock models, the results indicate that changes in the margin between premiums and underwriting expenses are negatively related to lagged values of capital relative to its long-run equilibrium value, where the latter variable is measured as capital relative its 5-year average, 3-year average, or GNP.

Aggregate Line Specific Studies. Gron (1994b) examines aggregate time series data for four lines of business: auto physical damage, auto liability, homeowners' multiple peril, and other liability. Unlike her time-series study of aggregate industry data (1994a), she examines the determinants of the underwriting profit margin, defined as earned premiums minus incurred losses, divided by earned premiums. After controlling for expected inflation, unexpected inflation, changes in expected inflation, and changes in discount rates, she finds that deviations of relative capacity (surplus to GNP) from its normal level are negatively related to underwriting profits in all four lines, which is consistent with the notion that prices increase when capacity (insurer capital) is reduced.

Panel Data Studies. The model developed by Cummins and Danzon (1997) emphasizes that price and capital are jointly determined. They therefore estimate a two-equation system using insurer level data, where price depends on lagged capital (as a measure of financial quality) and additions to capital depend on the change in price. Their results indicate that insurers with more capital charge higher prices, which is consistent with the risky debt notion of insurance policies. In addition, they find that price is inversely related to deviations of capital from normal levels, which lends support to the capital shock models. The capital equation results support the notion

sudden events could provide evidence of capacity effects on prices if the stock price response could be compared to the direct losses from the shock. Because the full magnitude of losses becomes known slowly over time, it is difficult, however, to construct a powerful test. Any changes in demand or price regulation due to the shock could also confound the results.

[33] During the 1980s, however, the correlation between domestic insurer capital and the economic loss ratio was negative. Winter argues that the 1980s can be explained in part by the omission of reinsurance capacity from the capital variables.

that insurers have an optimal capital structure and that capital is more likely to be raised following an increase in price.

Doherty and Garven (1995) use panel data to estimate the sensitivity of insurer underwriting returns to interest rate changes. They then regress these sensitivity measures on measures of surplus duration and proxies for the cost of raising capital (e.g., privately-owned and mutual companies are assumed to have higher costs of raising capital). They find that the interest rate sensitivity coefficient from the first pass regression is negatively related to surplus duration. This finding suggests that if interest rates increase, thus causing the long-run equilibrium underwriting return to decrease, insurers with a high surplus duration and therefore a large decrease in capital from the interest rate increase will adjust less rapidly to the lower equilibrium price. Thus, capital shocks caused by interest rate fluctuations influence price adjustment. They also find that privately-owned insurers adjust more slowly to interest rate changes, which is consistent with these insurers having greater capital adjustment costs.

Froot and O'Connell (1997) test the extent to which shocks in one insurance market influence pricing in other markets. In particular, they present evidence that catastrophe reinsurance prices changed across the board in response to shocks caused by specific types of catastrophes (e.g., a hurricane) or by catastrophes in specific regions. This evidence suggests that insurance prices vary inversely with insurer capital in the short run.

Shocks and Optimal Sharing of Correlated Risk

In a study that is closely related to the capital shock literature, Doherty and Posey (1997) develop a model that results in rationing of coverage (also see the discussion in Winter (1991a, 1994)). Following Dionne and Doherty (1997) and Marshall (1974), their model pursues the idea that the risk associated with correlated losses optimally should be shared between insurers and policyholders based on their relative costs of bearing risk (risk aversion for consumers and presumably capital costs for insurers). The ideal policy (ignoring moral hazard, adverse selection, and transaction costs) would pay all policyholder-specific losses, but would share losses that are economy-wide. Price increases following systematic losses would be consistent with such a sharing rule. The ideal contract is not feasible, however, because stock insurers have an incentive to falsely attribute losses to systematic events. Doherty and Posey therefore suggest that insurers can signal that aggregate losses occurred by selling less coverage than would be optimal at the higher price. In essence, by rationing coverage, insurers forego profits, which credibly signals that systematic losses occurred. The main predictions of this model are that premium revenue is negatively related to the magnitude of losses in the previous period and that the price response for mutuals will be less than for stocks given the reduced incentive for mutuals to dissemble. Their analysis of panel data for general liability insurers during the 1980s support these predictions.

20.5 PRICE CUTTING AND SOFT MARKETS

The traditional view of underwriting cycles by insurance industry analysts emphasizes fluctuations in capacity to write coverage as a result of changes in surplus and insurer expectations of profitability on new business (see Stewart, 1984; also see Berger, 1988). The essence of this explanation is that supply expands when expectations of profits are favorable, that competition then drives prices down to the point where underwriting losses deplete surplus, and that supply ultimately contracts in response to unfavorable profit expectations or to avert financial collapse. Price increases then replenish surplus until price-cutting ensues again.

The traditional explanation of supply contractions is largely consistent with shock models. The apparent missing link in this story, however, is why competition in soft markets ultimately leads to inadequate rates. Compared to the wave of research on shock models, there has been relatively little rigorous analysis of this issue. Instead, the traditional explanation of cycles has been appropriately challenged by researchers because it fails to explain how and why competition would cause rational insurers to cut prices to the point where premiums and anticipated investment income are insufficient to finance rational forecasts of claim costs and ensure a low probability of insurer default.[34] Thus, it could be that the data and evidence on predictability are soft (pun intended), rather than insurance prices during soft market periods.

Assuming that there is something to explain, what might explain soft markets culminating in inadequate rates? Winter's model implies that hard markets that follow large shocks tend to be preceded by periods of excess capacity and soft prices. However, as suggested earlier, shocks should be unpredictable. Neither Winter's model nor other shock stories can tightly explain second-order autoregression in profits.

Alternatively, it has been suggested that a tendency towards inadequate prices might arise from differences in insurer expectations concerning the magnitude of future loss costs (McGee, 1986, and Harrington, 1988; also see the comments in Stewart, 1984), from differences in insurer incentives for safe and sound operation (Harrington, 1988), or both.[35] Harrington and Danzon (1994) develop and test hypotheses based on this intuition and the large literatures on optimal bidding and moral hazard within the framework of alleged underpricing of commercial general liability insurance during the early 1980s. In the Harrington and Danzon analysis, some firms may price below cost because of moral hazard that results from limited liability and risk-insensitive guaranty programs. Others may price below cost due to heterogeneous information concerning future claim costs that results in low loss forecasts relative to rational forecasts accompanied by winners' curse effects. In

[34] Similarly, popular explanations of "cash flow underwriting" usually imply that insurers are irrational in that they reduce rates too much in response to increases in interest rates.

[35] McGee (1986) speculated that insurers with optimistic loss forecasts may cause prices to fall below the level implied by industry average forecasts. Winter (1988, 1991a) mentions the possibility of heterogeneous information and winner's curse effects.

response to underpricing by some firms, other firms may cut prices to preserve market share and thus avoid loss of quasi-rents from investments in tangible and intangible capital.

Harrington and Danzon use cross-section data from the early 1980s to test whether moral hazard and/or heterogeneous information contributed to differences in general liability insurance prices and premium growth rates among firms. Loss forecast revisions are used as a proxy for inadequate prices.[36] Estimation of reduced form equations for loss forecast revisions and premium growth and a structural model to test for a positive relation between premium growth and forecast revisions provides some evidence that is consistent with the moral hazard hypothesis.[37] An implication of this analysis is that increased market or regulatory discipline against low priced insurers with high default risk would reduce price volatility.

20.6 REGULATORY INFLUENCES

Delays in the rate approval process under prior approval rate regulation could influence or even cause cyclical fluctuations in underwriting results (Cummins and Outreville, 1987). Many studies analyze whether rate regulation affects cyclical movements in statewide loss ratios (see, e.g., Witt and Miller, 1981; Outreville, 1990; Tennyson, 1993; Harrington, 1984).[38] Most of these studies consider the hypothesis that regulatory lag amplifies cyclical movements in underwriting results. The basic story is that regulatory lag increases loss ratios in hard markets by delaying rate increases and reduces loss ratios in soft markets by delaying rate reductions. Alternatively, rate regulation could conceivably damp cycles by preventing excessive price-cutting in soft markets. Other research argues that rate regulation may have little effect on loss ratios for many commercial lines due to widespread use of schedule rating and other procedures that provide insurers with substantial flexibility in pricing even when rates are regulated (Stewart, 1987).

Empirical analyses of the effects of rate regulation on variability of loss ratios over time generally employ auto insurance data prior to the mid-1980s. Some studies provide evidence that rate regulation amplifies movements in loss ratios (e.g., Witt

[36] Loss forecast revisions will reflect moral hazard induced prices assuming that low price firms deliberately understate initial reported loss forecasts to hide inadequate prices from regulators and other interested parties, but that positive forecast errors materialize as paid claims accumulate. In addition, if prices vary due to differences in loss forecasts at the time of sale, less-informed firms should experience relatively greater upward forecast revisions over time as information accumulates.

[37] Specifically, forecast revisions and premium growth were generally positively and significantly related to the amount of liabilities ceded to reinsurers, consistent with the moral hazard hypothesis that reinsurance was used to conceal low prices and excessive growth. In addition, they find that mutual insurers generally had significantly lower forecast revisions and premium growth than stock insurers, which they argue is consistent with mutuals being less prone to low pricing due to moral hazard.

[38] Note that our focus here is on rate regulation and volatility, as opposed to the literature that suggests chronic effects of rate regulation on rate levels.

and Miller, 1981; Outreville, 1990), and, using cross-country data, that rate regulation increases the period of cycles (Lamm-Tennant and Weiss, 1997). Tennyson (1993) provides evidence that dependence of current inverse loss ratios for automobile insurance on lagged values is significantly larger in states with prior approval regulation. On the other hand, comparisons of average commercial lines loss ratios over time in states with prior approval and competitive rating laws suggest little effect of type of rating law (Stewart, 1987).

Another issue that has received attention is whether solvency regulation affects premium volatility. As noted earlier, explicit or implicit regulatory constraints on the maximum permissible ratio of premiums to surplus could amplify cycles (Winter, 1991b). This could occur if premium increases in hard markets and associated increases in the ratio of premiums to surplus were to cause some insurers to reduce output further, thus producing higher prices, in order to meet regulatory constraints on the maximum permissible ratio. Whether such constraints lead to undesirable reductions in output for enough firms to have a material effect on prices is arguable.

Finally, some authors discuss whether cooperative pricing activities in conjunction with the insurance industry's limited exemption from federal antitrust law might aggravate hard markets (e.g., Abraham, 1988; also see Angoff, 1988, for allegations of price fixing, and Ayres and Siegelman, 1989).[39] The McCarran-Ferguson Act exemption applies to the extent that these activities are regulated by the states or unless boycott, coercion, and intimidation are involved.[40] Other studies argue that these effects are difficult to reconcile with the industry's competitive structure, with the modern operation of advisory organizations, or both (e.g., Clarke, et al., 1988; Winter, 1988; Harrington and Litan, 1988; Harrington, 1990; also see Danzon, 1992, Gron, 1995, and Lacey, 1988).

In addition, analysis suggests that the activities of advisory organizations in auto insurance are (1) inconsistent with cartel behavior and (2) likely to be procompetitive (e.g., Danzon, 1983 and 1992). In most commercial insurance lines, independent rate filings, percentage deviations from ISO advisory rates or loss costs, and individual risk rating provide substantial flexibility in pricing. It also is argued that cooperative ratemaking activities for commercial lines are likely to enhance economic efficiency rather than amplify cyclical fluctuations or otherwise harm consumers (see Winter, 1988, and Harrington, 1990). If these activities reduce the likelihood of widespread underpricing in soft markets, they also may reduce premium volatility. In any case, the weight of the evidence suggests that price fixing is an unlikely cause of or contributing factor in hard markets.

[39] Two forms of cooperative activity have been subject to substantial controversy in recent years: the cooperative development of policy forms (see Ayres and Siegelman, 1989) and the development of advisory rates or prospective loss costs by advisory organizations such as the Insurance Services Office (ISO). For example, it is argued that advisory rates or loss costs stimulate price-cutting during soft markets and permit collusion to raise rates above costs during hard markets (Angoff, 1988).

[40] Many states have similar exemptions from state antitrust statutes.

20.7 CONCLUSIONS

There is no reasonable doubt that variation in insurance premiums over time and across buyers is largely attributable to variation in "fundamentals." However, there is substantial evidence that there is more to the story; i.e., that there sometimes is material variation in premiums that cannot be explained by the perfect markets model. The predictions of capital shock models are intuitively plausible, and there is some evidence consistent with their predictions. We know less about whether and why prices tend to fall too low during soft markets.

Additional theoretical work on capital shock models is needed to explore the relationship between costly external capital and capital structure decisions and pricing prior to any shock. Additional empirical work could provide evidence of the duration of any shock-induced price increases and whether costly external capital can explain both hard and soft markets. Unfortunately, it might be difficult to provide convincing evidence with respect to these issues using time series data because of the relatively small number of usable observations and the serious potential for data snooping bias. These problems suggest the need for more analyses that make creative use of cross-sectional (or panel) data.

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