Property-liability Insurance Underwriting Cycles

J. David Cummins

INSR825/230

Fall 2002

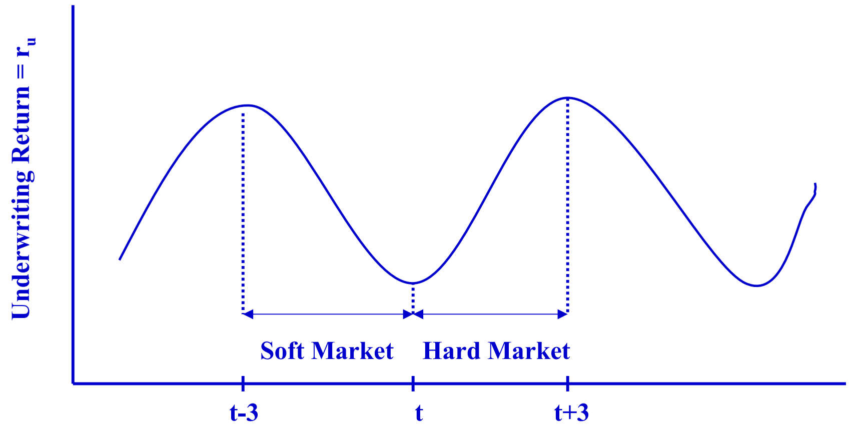
Defining Underwriting Profits

Underwriting profits = Premiums – Losses – Expenses

r_U = Return on underwriting = Und profits/Premiums
= 1 – Losses/Premiums – Expenses/Premiums
= 1 – Loss Ratio – Expense Ratio

$r_U > 0$ Underwriting Profit
$r_U < 0$ Underwriting Loss

Underwriting Cycles: Hard and Soft Markets



Why Underwriting Return Doesn't Tell the Whole Story

Net Income = Underwriting Income (UI)
+ Investment Income (II)

Return on Equity = Net Income/Equity
= UI/Equity + II/Equity
= r_U * (P/E) + A_I
= r_U * (P/E) + r_A * (A/E)

More About Return on Equity

Return on Equity = r_U * (P/E) + r_A* (A/E)

P/E = premiums to surplus ratio (insurance leverage)

A/E = assets to surplus ratio (investment leverage)

Implication of ROE Equation

Return on Equity = r_U * (P/E) + r_A* (A/E)

- r_U can be negative and ROE can still be positive as long as r_A is positive and investment earnings are sufficiently large

Further Analysis of ROE

Return on Equity = r_U * (P/E) + r_A* (A/E)

Assume that A = P + E and define k = P/E,

ROE = r_U * k + r_A* (P+E)/E

= r_U * k + r_A* (k+1) = r_A + k*(r_U+r_A)

Implications of ROE Model

ROE = r_A + k*(r_U+r_A)

- If P = 0 (firm writes no insurance), ROE = r_A and the firm is a mutual fund (Recall that k = P/S)
- If P > 0, ROE ≥ r_A as long as $r_U \geq - r_A$

Why r_u Should Be Negative I

Assume:

- Premiums (P) paid at time 0
- Losses (L) paid at time 1
- Interest rate = r_D
- Expenses = 0
- L is not random

Then: $P = L/(1+r_D)$

Why r_u Should Be Negative II

- Loss ratio = $L/P = L/[L/(1+r_D)] = 1+r_D$
- Underwriting return = r_u = 1 – Loss Ratio
- $r_u = - r_D$
- $\therefore$ r_D = interest paid for use of policyholder funds

ROE Model Revisited

- Because $r_U = - r_D$ in competitive equilibrium,
- $ROE = r_A + k^*(r_U+r_A) = r_A + k^*(-r_D+r_A)$
- $\rho = r_A - r_D$ = "net interest margin," and
- $ROE \geq r_A$ as long as $r_A - r_D > 0$

Possible Sources of Profit Cycles

Recall: $ROE = r_A + k^*(r_U+r_A)$

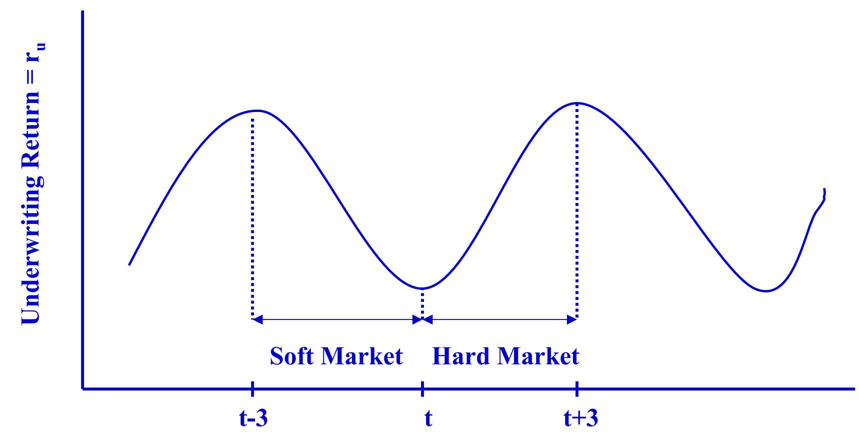
r_U = 1 – Losses/Premiums

- ROE cycle could come from cycles in:
  - r_A ,
  - Losses , and/or
  - Premiums
- Expenses are not cyclical so it is safe to ignore expenses for modeling purposes

Research Findings:

- Losses are not cyclical
- Cycles primarily come from premium changes triggered by
  - Interest rate shocks
  - Loss shocks

Recall the Underwriting Cycle Graph



Mathematical Representation of the Cycle

$r_{u,t} = a_0 + a_1\, r_{u,t-1} + a_2\, r_{u,t-2} + \omega_t$

Cycle is present if:

- $a_1 > 0$
- $a_2 < 0$
- $a_1^2 + 4\, a_2 < 0$

Formula for Cycle Period

Recall: $r_{u,t} = a_0 + a_1\, r_{u,t-1} + a_2\, r_{u,t-2} + \omega_t$
Assume $a_1 > 0$, $a_2 < 0$, and $a_1^2 + 4\, a_2 < 0$

Then Period = $P = 2\pi/\text{acos}(a_1/(2\sqrt{-a_2}))$

where acos = arccosine [if cos(x) = r, then arccosine(r)=x]

Example: If $a_1 = 0.9$ and $a_2 = -0.8$, then $a_1^2+4\, a_2$ and $P = 2\pi/\text{acos}(0.503115) = 6.557$.

Implication of Cycle Formula

Recall: $r_{u,t} = a_0 + a_1 r_{u,t-1} + a_2 r_{u,t-2} + \omega_t$

If a_1 and a_2 are non-zero, then $r_{u,t}$ is second-order autoregressive, i.e.,

$E(r_{u,t} r_{u,t-1}) \neq 0$

$E(r_{u,t} r_{u,t-2}) \neq 0$

and $r_{u,t}$ is correlated with its own lags.

If we can determine the source of autocorrelation, we may have a clue regarding the cause of cycles.

Rational Expectations I

- Now assume that L is random but insurer estimates of E(L) are unbiased so that:
  - $L_t = E(L_t) + \epsilon_t$
  - $\epsilon_t \sim N(0,\sigma_\epsilon)$, i.e., ϵ_t is "white noise"
  - $E(\epsilon_t \epsilon_{t-i}) = 0, i \neq 0$
- Also assume: $r_D = 0$

Rational Expectations II

Then underwriting profit is:

$\Pi_U = P - L$

$= E(L) - L$

$= E(L) - [E(L) + \epsilon_t]$

$= -\epsilon_t$

$r_U = \Pi_U/P = -\epsilon_t/P$

$\Rightarrow$ r_U cannot be autocorrelated under RE, because ϵ_t is white noise

Rational Expectations III

If r_u is empirically observed to be autocorrelated, then:

- Insurance pricing does not follow RE, i.e., insurers make systematic pricing errors

or

- Autocorrelation enters r_U in some other way

Rational Expectations IV

Assuming that insurers are RE decision makers, i.e., that they utilize all available information in pricing, how could autocorrelation enter observed r_U? Two possible explanations:

- Pricing lags
- Accounting conventions

Insurance Pricing Lags: Pricing at Time t (end of year t)

Center of loss data	t – 0.5
Data available to actuaries	t + 0.25
Rates filed with regulator	t + 0.5
Rates approved by regulator	t + 1.0
Average renewal date	t + 1.5
Avg claim under new rates	t + 2.0
Total elapsed time	2.5 years

Rational Pricing With Lags I

Model of loss evolution:

$L_t = E(L_t) + \epsilon_t + \nu_t$

where ϵ_t = "transitory" error

ν_t = "permanent" error

$\therefore\ E(L_{t+1}) = E(L_t) + \nu_t$

Rational Pricing With Lags II

Assume pricing at time t using data that are one year old, i.e., due to lags, insurer does not observe ν_t and sets price as follows:

$P_{t+1} = E(L_t)$

Rational Pricing With Lags III

$\Pi_{U,t+1} = P_{t+1} - L_{t+1}$

$= E(L_t) - [E(L_{t+1}) + \epsilon_{t+1} + \nu_{t+1}]$

$= E(L_t) - [E(L_t) + \nu_t + \epsilon_{t+1} + \nu_{t+1}]$

$= - (\nu_t + \epsilon_{t+1} + \nu_{t+1})$

Likewise, $\Pi_{U,t} = - (\nu_{t-1} + \epsilon_t + \nu_t)$

$\therefore E(\Pi_{U,t+1} \Pi_{U,t}) = E(\nu_t^2) \neq 0$

Accounting Averaging: 2nd Order Effect

Insurance accounting leads to averaging of prices from different time periods, i.e., reported underwriting profits are:

$\Pi^R_{U,t+1} = \alpha \Pi_{U,t+1} + (1- \alpha) \Pi_{U,t}$

$\Pi^R_{U,t+1} = f(\nu_{t-1}, \nu_t, \nu_{t+1})$

and $\therefore$ $\Pi^R_{U,t+1}$ is 2nd order autoregressive, a function of its own lagged values

Implications of Model

With data lags and accounting averaging,

- Observed r_U will be cyclical, even if insurers price according to rational expectations
- Therefore, the cycle is at least partly *illusory*

Hypotheses

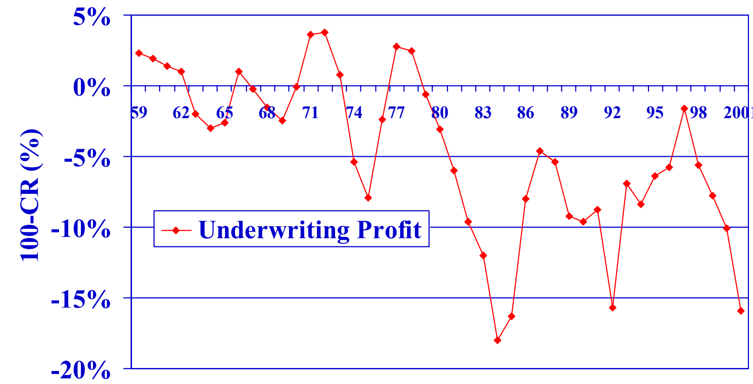
The model predicts that:

- H1: r_U will be second order autoregressive
- H2: r_U will be inversely related to interest rates

Traditional Finding

- Underwriting profits are cyclical
- The cycle is approximately 6 years in length (Cummins & Outreville 1987, and numerous other researchers)

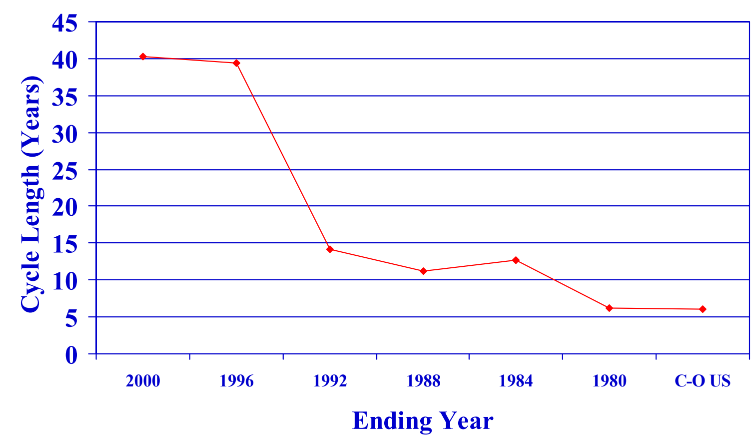
The P/L Underwriting Cycle



Underwriting Profit Regressions

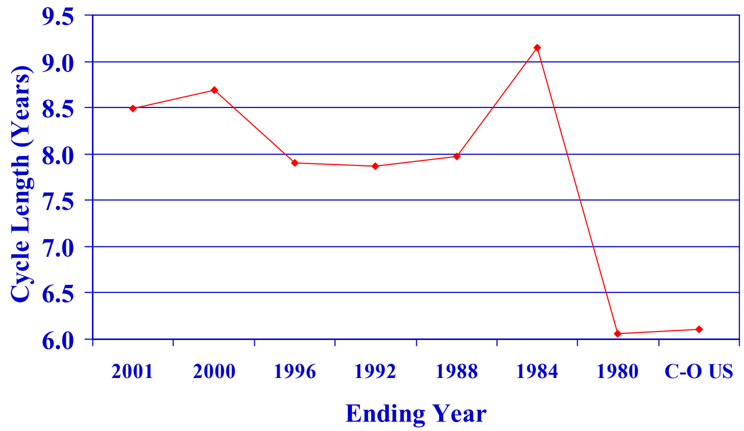
UNDERWRITING PROFIT REGRESSIONS 1961-1980 & 1981-2001								
Method: Least Squares				Method: Least Squares				
Sample: 1961-1980				Sample: 1981-2001				
Included observations: 20				Included observations: 21				
Variable	Coefficient	Std. Error	t-Stat	Variable	Coefficient	Std. Error	t-Stat	Prob.
C	-0.55	0.36	-1.54	C	-5.55	2.04	-2.72	0.02
ULOSSL1	0.93	0.14	6.63	ULOSSL1	0.66	0.24	2.69	0.02
ULOSSL2	-0.82	0.14	-5.95	ULOSSL2	-0.25	0.23	-1.10	0.45
R-squared	0.755			R-squared	0.333739			
Adjusted R	0.727			Adjusted R	0.255356			
Conditions for Cycle:				Conditions for Cycle:				
a1 > 0		Yes		a1 > 0		Yes		
a2 < 0		Yes		a2 < 0		Yes, not significant		
a1^2 + 4 a2 < 0		Yes		a1^2 + 4 a2 < 0		Yes		
Cycle Period		6.10		Cycle Period		7.35		

The Vanishing Underwriting Cycle? Cycle Length: 1960 to Ending Year

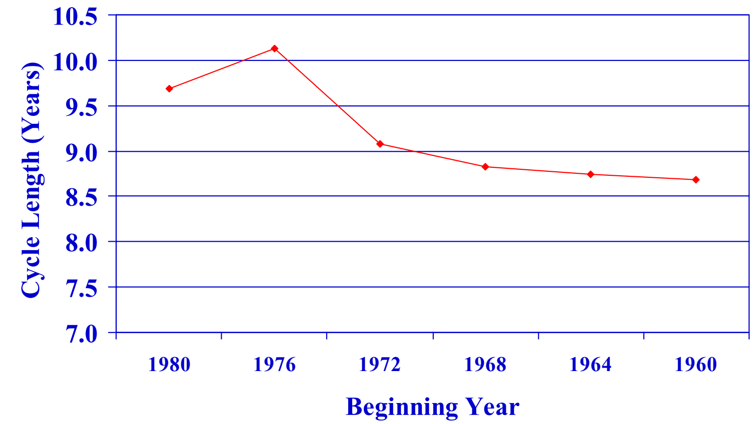


Note: Cycle length from 1960-2001 is undefined (does not exist mathematically).

Time Trend Corrected Cycle Length: 1960 to Ending Year



Time Trend Corrected Cycle Length: 2000 to Beginning Year



Why the Cycle May Be Lengthening or Vanishing

- Computer technology has reduced data lags
- Price regulation has become less stringent:
  - Workers' compensation "loss cost" filings
  - Commercial lines deregulation
- Price changes are more frequent due to intensified competition

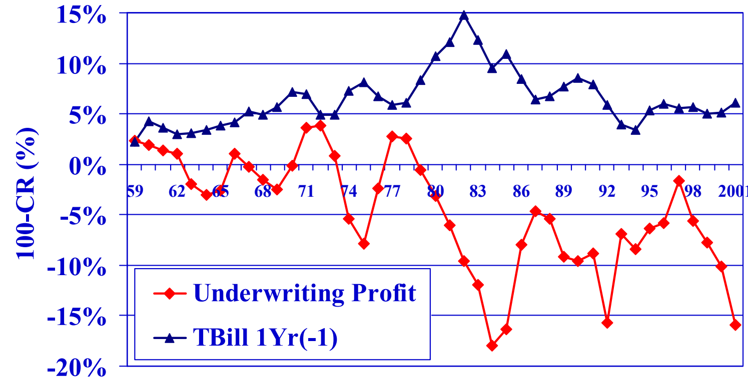
Conclusion: Hypothesis I

- H1: Underwriting profits are second order autoregressive
- Result: Mixed support
  - Strong support prior to 1980s
  - Cycle may be lengthening
  - Cycle may be disappearing (2nd order term insignificant in most recent periods)

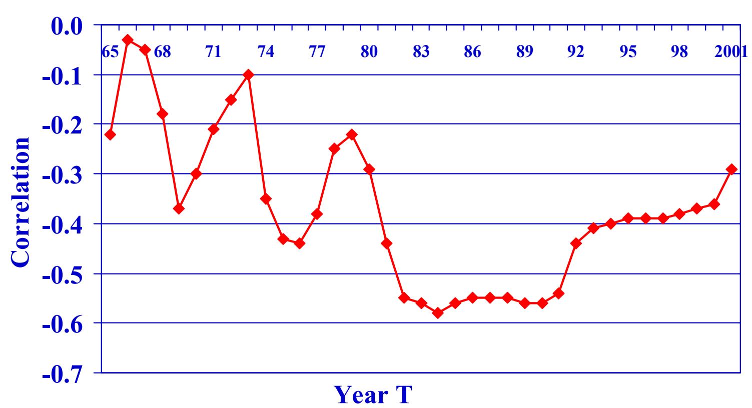
Investigating H2: Interest Rates

- H2: Underwriting profits are inversely related to interest rates

Underwriting Profit versus 1 Year Treasury Bill Yield (Lagged one year)



Correlation Between Underwriting Profit and T-Bill Rate: 1958-Year T



Underwriting Profit and Interest Rates: AR(1) Regression: 1961-2001

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.542	4.151	1.576	0.146
TBILL(-1)	-0.774	0.372	-2.079	0.044
TIME	-0.311	0.128	-2.436	0.042
AR(1)	0.634	0.140	4.531	0.000
R^2	0.674	Mean DepVar		-5.188
Adj R^2	0.647	S.D. DepVar		5.599

Conclusion: Hypothesis 2

- Strong support: Univariate and multivariate results show an inverse relationship

"Real Cycles": Hard and Soft Markets

Traditional cycle may be partly illusory and lengthening, but hard and soft markets seem to persist.

- Hard market: Supply of coverage is limited and prices are high
- Soft market: Supply of coverage is high and prices are low

Explanations for Hard/Soft Markets I

- Supply side view (naïve)
  - When underwriting profits are high, companies cut prices to gain market share and obtain funds to invest (*cash flow underwriting*).
  - Prices and profits fall until insurers incur "excessive" underwriting losses and are forced to reduce supply and raise prices.

Explanations for Hard/Soft Markets II

- Supply side view (more sophisticated)
  Recall: $ROE = r_A + k^*(r_U+r_A) = r_A + k^*(-r_D+r_A)$
  - When net interest margin $(r_A - r_D) > 0$, insurers cut prices (raise r_D) to gain market share and obtain assets to invest (*cash flow underwriting*).
  - Due to unexpected interest rate or underwriting shocks, $\Delta r_A < 0$ or $\Delta r_u < 0$, leverage ratios (e.g., premiums/surplus) become "too high"
  - Insurers cut supply (reduce premium writings) and increase prices to reduce leverage to "more acceptable" levels

Sophisticated Supply Side View: Predictions

- Hard markets follow adverse interest rate and underwriting shocks
- Soft markets follow favorable interest rate and underwriting shocks
- Relatively large changes in leverage ratios trigger market turning points

Underwriting Profit, Interest Rates, and Leverage (Prem/Surplus): 1961-2001

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.76	3.26	-0.54	0.592
TBILL1	-1.06	0.28	-3.82	0.0005
TIME	-0.17	0.06	-2.74	0.0095
PS1	5.47	2.19	2.49	0.0174
R^2	0.568	Mean DepVar		-5.027
Adj R^2	0.533	S.D. DepVar		5.623

Changes In Und Profit, Interest Rates, and (Prem/Surplus): 1961-2001

- Dependent Variable = Log[CRAD/CRAD(-1)]

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.02	0.01	2.41	0.0225
D[TBILL(-1)]	0.06	0.03	2.16	0.0392
D[Surplus(-1)]	-0.27	0.10	-2.68	0.0119
D[Prem/Surp(-1)]	-0.32	0.11	-3.01	0.0054
R^2	0.350	Mean DepVar		0.004
Adj R^2	0.283	S.D. DepVar		0.037

Discussion of Regression

- Hard markets driven by shocks (changes in)
  - Investment return shocks
  - Underwriting return shocks
  - Increases in leverage ratios
- Regression considers
  - Change in Combined Ratio
    - Increases associated with soft markets
    - Decreases association with hard markets
  - In response to changes in interest rates, equity, and leverage

Why the Lags?

- Premiums can't be adjusted instantaneously (see discussion of lags above)
- Needed to avoid merely modeling accounting relationships, e.g., if underwriting returns are high this year, surplus will go up because end of year surplus is a function of the same year's underwriting profit (loss), lagging helps to deal with this problem

Conclusions: Supply Side View

- Hypothesis: Hard markets driven by shocks to
  - Investment return
  - Underwriting return
  - Leverage ratios
- Results
  - Increases in equity inversely related to combined ratio change – more equity reduces combined ratio, contrary to supply side view
  - Increases in P/S ratio inversely related to combined ratio change – more leverage reduces combined ratio, supporting supply side view

Conclusions: Supply Side View II

- Hypothesis: Hard markets driven by shocks to
  - Investment return
  - Underwriting return
  - Leverage ratios
- Results
  - Increases in interest rates associated with increase in combined ratio – consistent with pricing model, neutral with respect to supply side view
- Conclusion – there is mixed evidence regarding the predictions of supply-side interpretation of cycle

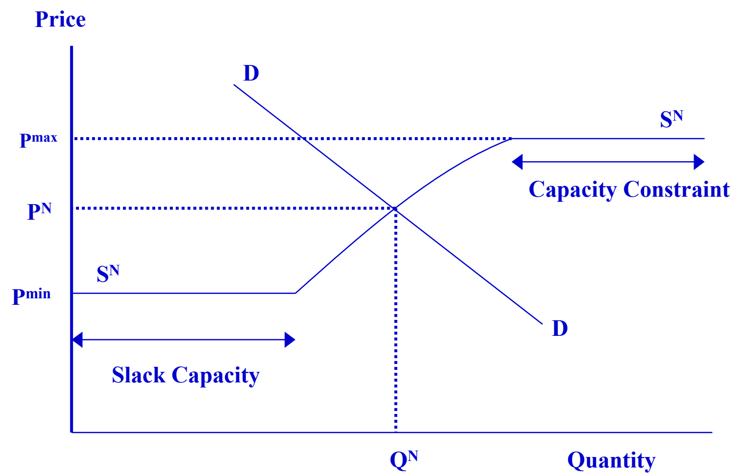
Explanations for Hard/Soft Markets III: The Capacity Constraint Theory

- Capacity constraint theory (Winter 1994) Formalizes the sophisticated supply side hypothesis and introduces demand.

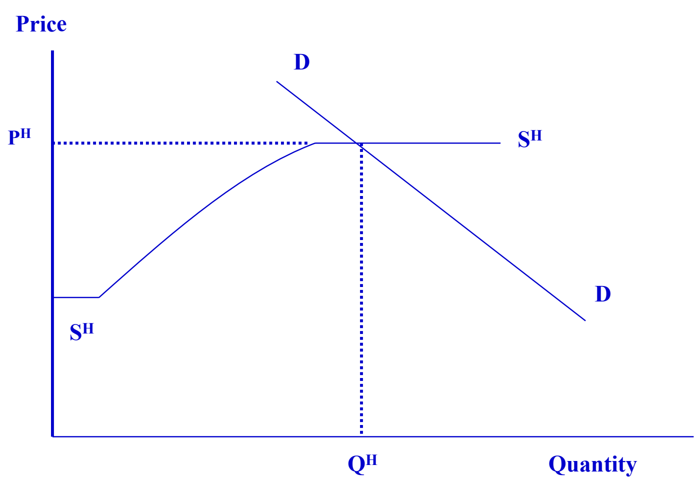
Capacity Constraint Theory: Key Assumptions

- Insured losses are correlated – so insurers hold equity to guarantee promise to pay claims
- Insurers hold sufficient capital to reduce insolvency probability to zero
- External capital more costly than internal capital

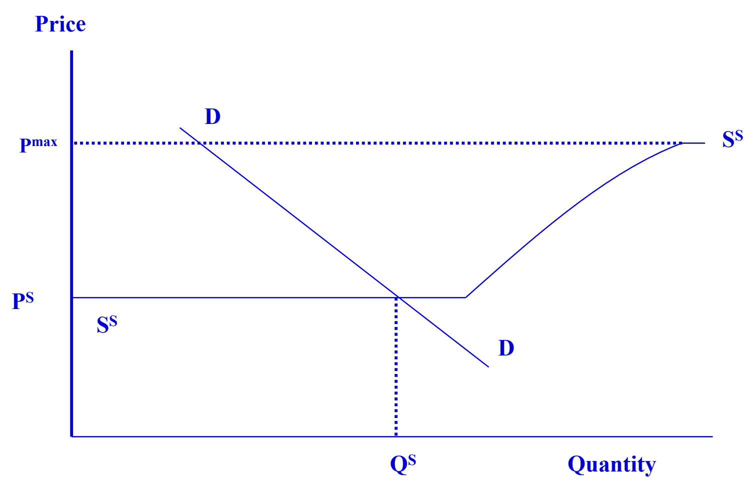
Capacity Constraint Theory: Normal Equilibrium



Capacity Constraint Theory: Hard Market



Capacity Constraint Theory: Soft Market



Capacity Constraint Theory: Empirical Prediction

$P = PV(L)\ (D/K)^a\ e^{\epsilon}$

$\log[P/PV(L)] = a \log(D) - a \log(K) + \epsilon$

where P = price, L = expected losses, D = demand, K = capital, ϵ = random error, and

[P/PV(L)] = "economic premium ratio"

Prediction: $a > 0$

Capacity Constraint Theory: Further Discussion

- The theory predicts that:
  - Hard markets occur when demand is high relative to capital (capital constraint)
  - Soft markets occur when capital is high relative to demand (slack capacity)
- To test: Define
  $Relcap = Surplus_t / Average(Surp_{t-1}:Surp_{t-5})$

Capacity Constraint Theory: Dependent Variable = Premium/Losses, 1961-2000

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.923	0.045	20.701	0.000
TBILL1	-0.007	0.003	-2.894	0.007
TIME	-0.003	0.001	-3.307	0.002
RELCAP	0.115	0.029	3.955	0.000
AR(1)	0.606	0.139	4.369	0.000
R^2	0.782		Mean Dep Var	0.956
Adj R^2	0.757		S.D. Dep Var	0.048

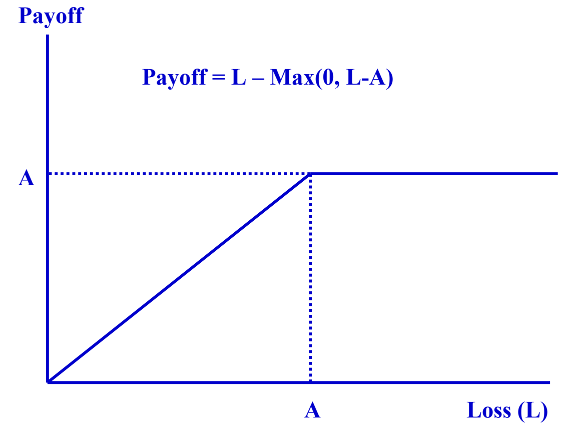
Conclusion: Capacity Constraint Theory

- Theory predicts Relcap inversely related to price ratio but regression shows positive relationship
- There is some support for the theory elsewhere in the literature
  - However, it fails to predict prices during the 1980s liability crisis (Winter, Gron)

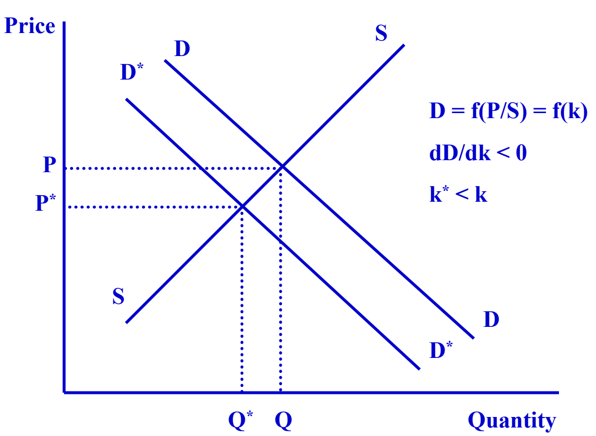
Risky Debt Hypothesis

- Insurance is priced as risky debt (i.e., insolvency can occur – opposite of capacity constraint hypothesis)
  - Price = E(L) – E[Max(0, L-A)]
    = expected loss – insolvency put option
- Demand for insurance is inversely related to expected insolvency costs – therefore, insurers have optimal capital structure
- Insurers have some market power, allowing some control over prices

Risky Debt Hypothesis: Loss Payoff to Policyholders



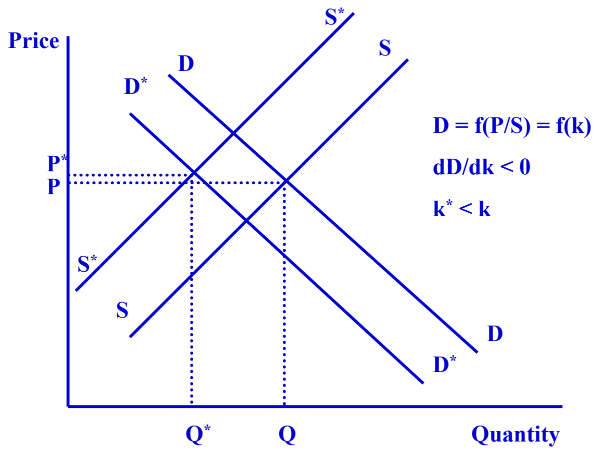
Risky Debt Hypothesis: Supply and Demand



Risky Debt Hypothesis: Hard Market Scenario

- Shock to capital occurs driving insurers away from optimal capital structure
  - $P^*/K^* > P/K$
- Insurers restrict supply – restore optimal capital structure through retained earnings
- If price increase is sufficient, insurers will raise external capital

Risky Debt Hypothesis: Supply and Demand



Risky Debt Hypothesis: Predictions

- Price will be inversely related to leverage: higher P/S ⇒ lower prices because of higher default risk
- Quantity supplied will fall and price may increase following a capital shock
- Insurers will raise capital following a shock-induced price increase

Capacity Constraint vs Risky Debt

- Capacity constraint: High capital implies relatively low price because of slack capacity
- Risky debt: High capital implies relatively high price due to lower insolvency risk

Reconciling the Capacity Constraint and Risky Debt Models

- Capacity constraint could hold for the market as a whole (time series relationship)
- Risky debt model could explain price differences among insurers at any given time (cross-sectional relationship)

Underwriting Cycles: Conclusions

- The underwriting cycle is at least partly an illusion resulting from pricing lags and accounting rules
- Insurance prices are inversely related to interest rates
- Hard and soft markets are caused by unfavorable and favorable loss or investment shocks

Underwriting Cycles: Conclusions II

- Empirical evidence provides only mixed support for the capacity constraint theory's prediction of an inverse relationship between price and capital
- Empirical evidence provides stronger support for the risky debt theory's prediction of a positive relationship between price and capital
- Supply is restricted and prices rise following an adverse shock to capital
- Insurers tend to raise new external capital following a shock-induced price increase