

**Great (and not so Great) Expectations: An Endogenous
Economic Explication of Insurance Cycles and Liability Crises¹**

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¹ This paper is best read in its electronic form (or with access to its electronic form) as it contains animations of evolving supply and demand curve intersections creating equilibrium prices for insurance contract. While the paper itself is self-contained, the animations visually illustrate the existence of cycles and crises with a liveliness not possible with mere equations and comparative statics. The animations can be found on the internet at <http://kiwiclub.bus.utexas.edu/crisis/crisis.html>.

INTRODUCTION

Insurance cycles² have been recognized for decades, and have been the object of study by academic investigators for as long (c.f., Cummins 1987)). The reason for this intense study is both basic (theoretical) and practical. At a basic level, questions arise as to whether such cycles are in conflict with rational corporate decision-making in an efficient financial market. From a practical perspective such cycles can, at their extremes most valleys, create crises in affordability and availability of insurance effecting the very productivity of the country involved. The liability insurance crisis in the United States from late 1984 through 1986 is an example of such an extreme in the insurance cycle, being characterized by significant economic disruptions in commercial liability insurance markets. The disruptions created concerns about both availability and affordability of certain coverages. For example, professional and commercial liability insurance consumers were adversely affected by the crisis, as were others such as chemical and pharmaceutical companies, day-care centers, doctors, and municipalities. The cycle ultimately resulting in the crisis was characterized by a sudden increase in liability premiums in late 1984 after about six years of relatively stable prices. An additional response to changes in this cycle included the lowering of policy limits and a reduction in scope of coverage in commercial liability lines that were characterized by long-tails. In addition, insurers were unwilling

² There is some confusion in the literature regarding exactly what quantity is being called cyclic. Some papers refer to the cyclic nature of underwriting profit, some refer to the cyclic behavior of loss ratios (or combined loss ratios), some refer to prices, and some refer to availability. One must be careful when comparing across the literature to be sure you are comparing apples to apples. This paper considers cycles in insurance prices and availability (simultaneously determined). Our model could be adjusted to address the other topics of cycles, but this is not done here in the interest of space.

to provide any coverage at all for some risks, e.g., those involving pollution liability exposures.³

Academics, attorneys general, consumers, insurers, and regulators have not agreed upon the causes of insurance cycles, and the causes of the commercial liability insurance crisis of the late 1980s is still debated. The cycles and crisis theories that do appear in the literature share at least two common characteristics. First, the theories focus on the supply of liability insurance and ignore the demand. Although it is implicit in some theories, the demand for liability insurance during the cycles and crisis are generally not addressed. Second, the theories emphasize a single factor as the cause of the crisis or cycle (although what exactly is the single factor has varied from explanation to explanation).

This shared single factor approach to insurance cycle and crisis explications create problems. Firstly, these single factor theories do not explain enough aspects of the crisis, even though each offers some insight. For example, the U. S. Justice Department (Justice 1986) has cited the expansion of business liability under tort law as the factor explaining higher premiums and reduced coverage limits. The expansion of business liability under tort law, however, has been occurring over a far more extended period, this fact coupled with the fact that increases in claim frequency and severity were relatively steady during the early 1980's, makes it difficult to accept this factor as the primary (or only) cause of either the sudden elimination of some

³Another characteristic of the crisis for insurers was the low rate of return on their policyholders' surplus during 1984 and 1985 before increased premiums improved profitability. For a more detailed discussion of the commercial liability insurance crisis, see 1986; Clarke and et al. 1988; Harrington and Litan 1988; Harrington 1988; Lacey 1988; Winter 1988; Lai and Witt 1992.

liability coverages or the sudden increase in commercial premiums.⁴ In fact, single factor hypotheses do not explain why net written premiums for general liability insurance increased from about \$6.5 billion in 1984 to approximately \$19.5 billion in 1986.⁵

Due to the single factor nature of the current explanations, the literature remains fragmented and unsettled. For example, Priest (Priest 1987) criticized the "capacity constraint hypothesis" advanced by Winter (Winter 1988) on the grounds that it was not clear that insurance capacity had, in fact, been exhausted. Priest noted that "The property/causality premium-to-surplus ratio in December 1984 was 1.85 and in December 1985 was 1.91, both figures are far below the prudent or commission-mandated ratios of 4:1 and 3:1."⁶ Similarly, Winter (Winter 1988) questioned the "adverse selection hypothesis" suggested by Priest. He argued that if the adverse selection hypothesis led to the crisis of 1985, then this cause would have implied that profit rates would have dropped and the rate of entry of capital into the industry would have decreased, but neither was the case. Similar criticisms of explanations of insurance cycles in their more placid exhibitions may be also presented.

There are also empirical studies of insurance cycles (and crises), however the characteristic features of empirical studies on the liability crisis are similar to those of theoretical studies. First, very little empirical evidence about the demand for liability insurance has been developed. Second, on the supply side, most of the empirical studies are performed to test one specific single factor hypothesis rather than a

⁴See Table Two in (Winter 1988), p.873.

⁵This reported increase is based on data from the A.M. Best Company.

⁶See (Priest 1997), p. 1531.

combination of several. The lack of empirical evidence on a more comprehensive basis is probably why Winter suggests that an "... open research question is what proportion of premium increases in 1984-86 were 'actuarially justified' by rationally expected increases in future claims."⁷

None of the existing hypotheses alone can explain enough aspects of the commercial liability insurance cycles, especially the large scale increases in premiums during the crisis period.⁸ Due to the unsettled nature of the literature, concerned parties are left to wonder what the actual causes of cycles and the liability crisis were. A theoretical framework that examines both supply and demand, and also incorporates multiple factors rather than a single factor is needed in order to develop a satisfactory explanation of more aspects of the crisis. This paper present such an explanation based on both supply side and demand side changing expectations of loss. It is the first time both supply and demand are incorporated into a single endogenous model explaining the economic theory behind insurance cycles.

The purpose of this paper, then, is to develop an economic model that can offer a more comprehensive explanation of cycles, and of its most extreme form, the commercial liability insurance crisis. The model integrates some of the competing hypotheses into a unified approach that can provide a coherent theory of the causes cycles and of the commercial liability insurance crisis. The model developed here also suggests some empirical verification of the ramifications of the economic model, and these are also explored. The proposed model,

⁷ See (Winter 1991), p. 133.

⁸ Currently, the Cummins-Danzon model comes closest to providing an integrated explanation, i.e., (Cummins and Danzon 1997). That analysis, however, does not

which is based on changing insurer and insured expectations of loss and risk, is used to examine what portion of premium increases in the crisis period could arise from factors consistent with a rational expectations framework in order to respond to Winter's suggestion. Finally, the model provides some insight on how to dampen future cycles and reduce the impact of future liability crises.

The premise here is that the crisis occurred due to changes in expectations on both sides of the market (i.e., supply and demand). The changes in insurer expectations reduced the supply of liability coverage. The increase in the perceived expected values and variances of future losses, in part due to a changing and expanding tort liability system, and in part due to the expected present value effects of a decrease in interest rates were all contributing causes of the crisis to the extent that they contributed to changed expectations. These changes help explain a smaller more inelastic supply that, on the demand side, simultaneously caused firms *ceteris paribus* to assume more of their own liability exposures. Those changed expectations also help theoretically explain a more inelastic demand. The increased inelasticity in demand would, *ceteris paribus*, have resulted in the maintenance or increase in coverage of liability exposures but the concomitant increases in the inelasticity of supply and demand amplified the effect of expectation based price increases and consequently resulted in reduced coverage. Hence, the changes in insurer expectations shifted the supply and the changes in consumer (insured) expectations amplified, rather than dampened, the cycle by shifting demand. Much like a harmonic oscillation in congruence, the

explicitly model demand and so is not an equilibrium analysis. Because of its structure it does not include some of the risk parameters included here.

supply and demand curves moved apart until market failure (or close to it) caused a crisis.

This study complements the literature on cycles and on the commercial liability insurance crisis in several ways. First, in contrast to the existing literature, this theory emphasizes several factors in explaining the liability insurance cycles and the ultimate crisis. Second, this theory completes existing theories by modeling the role of *insurance demand*, in addition to insurance supply (a duality which has been missing). Third, the paper provides new empirical evidence on the crisis using cross-sectional data. The results support the hypothesis that the crisis was caused by multiple factors. In addition, the regression model derived from the economic model can explain 59% of the variation in premium increases using cross-sectional data; hence, it is a response to Winter's question about what portion of the price increases were actuarially justified by rational expectations. A similar model could have been created that would explain more than 59% of the variation in premiums if the interest rate factor had been considered, however while this would provide additional explained variance, it would add complexity to the analysis. Moreover, interest rates were not included in this regression model because of limitations imposed by the cross-sectional analysis. However, a separate time series analysis is performed to provide evidence that the interest rate also played a role in the crisis. Finally, the paper provides some empirical evidence that rejects the mismanagement and greed hypothesis. In summary, the empirical evidence is consistent with the implications of the endogenous economic explication of insurance cycles and crises based on changing expectations on both the supply and demand side.

RELATED LITERATURE

What theories exist that explain cycles and their extreme form of crisis, or which might predict new crises? The literature is replete with explanations. The theories about the commercial liability crisis broadly fall into four categories. The first category consists of the collusion theories; that insurance companies colluded to drive prices up and availability down (again considering only the supply side of the market). The second category includes the loss-shock theories. In this realm Cummins and Danzon 1991, Gron 1990 and Winter 1986, 1988, and 1991 consider the role that loss-shocks experienced by insurers play in generating a crisis. The third category includes the interest rate theories, e.g., Doherty and Kang 1988, Doherty and Garven 1995. The fourth category consists of the under-pricing theories, e.g., Harrington and Danzon 1991. This literature remains fragmented but it has provided the basis for a consensus on the determinants of crises.

The anti-trust lawsuits filed by Attorneys General of nineteen states at the federal level and by the Attorney General of Texas at the state level in 1988 appeared to be premised on the collusion theory.⁹ This theory, however, has not received much support in the literature.¹⁰ The other theories form the basis for what has appeared to be a consensus.

⁹Federal anti-trust law applies to U.S. insurers only to the extent that insurance is not regulated by state law. However, conduct or acts involving boycott, coercion, or intimidation are not exempt from federal law, and this was the basis of the suit.

¹⁰This collusion and conspiracy hypothesis does not appear to be consistent with the competitive structure of the market for commercial liability insurance which has a large number of insurers providing somewhat differentiated products in terms of quality, marketing, underwriting, and claim settlement services. Collusion among a large number of insurers in each of the state markets for commercial liability insurance market is highly unlikely even with the limited anti-trust protection provided by the McCarran-Ferguson Act for business of insurance. For details, see Clarke and et al. 1988; Harrington and Litan 1988; Kimball 1988; Lacey 1988; Lai and Witt 1992.

Consensus

The elements that compose the basis for a consensus exist. Cummins, Harrington, and Klein (Cummins, Harrington et al. 1991) point to **loss shocks, interest rate changes, and under-pricing** as the determinants of cycles. They also mention " . . . instability in the underlying loss processes." The loss processes noted here, and investigated by Cummins and McDonald (Cummins and McDonald 1992), provide the motivation for an amendment to this list of crisis determinants. In the revised list, interest rate changes would be replaced with **expectation changes**. While the cause of the insurer experiencing expectation changes in prospective assessment of premium adequacy would include interest rates, the revised list would not be limited to interest rate changes, as other factors (such as changes in tort law, regulatory changes, and even changes in the natural environment) can influence expectation changes which in turn can effect rates set *a priori*. The changes would also include expectations regarding underwriting losses. The combined impact of all the changing expectations can have a dramatic effect on the structure of both the demand and supply in a competitive insurance market, as the analysis in subsequent sections will show.

Loss-Shocks. A loss-shock is a realized loss that draws down the insurer's surplus. A sufficiently large shock reduces the credibility of the insurer's ability to fulfill their contracts. A loss shock may have an impact on prospective determination of loss expectations by the insurer but the two concepts are different. The loss shock refers to the

past while the loss expectation refers to the future. A connection between the two, however, is discussed more fully in Brockett and Witt (1982) and relates to the actuarial methods which use of past data to set future premiums in an "empirical Bayes" or credibility theoretic fashion.

The discounted cash flow construct common to most economic theories of the insurance firm generates an insurance supply function that is perfectly elastic where the premium is the present value of the expected unit loss (with some adjustment for expenses, profit and risk contingency). Hence, the discounted cash flow approach makes it difficult to explain an observed decisive change in the premium without a similar change in the expected unit loss. The financial constraint construct, common in this thread of the literature, allows another such an explanation. In this theory, the firm is assumed to maintain a constant capital structure so that it can supply credible insurance contracts. There is also an assumption that external capital is too costly to generate after an extreme loss and so all equity capital is raised internally. Therefore, the financial constraint theory connects capital structure decisions with operating decisions because when losses sufficient to impact the constraint are incurred the firm will only supply additional insurance at prices sufficiently high that the firm is refinanced internally via premiums. This approach is contained in Winter 1986, 1988, 1991; Gron 1990; Cummins and Danzon 1991. Cummins and Danzon, (Cummins and Danzon 1997), provide a more rigorous theoretical foundation for loss-shocks that causally connect premiums, stock value, and surplus.

The National Insurance Consumer Organization (NICO 1986) suggested a "mismanagement and greed theory" but that argument, when

it makes sense, appears to fit into the loss-shock category.¹¹ According to the NICO argument the dramatic increase in commercial liability premiums was needed to compensate insurers for unexpected increases in past losses from the early 1980s.¹²

Interest Rate Changes. Interest rate changes affect all financial values and so must form part of any explanation, e.g., Doherty and Kang 1988. In this thread of the literature, the duration measure is sometimes used. If the asset and liability durations are not appropriately matched then interest rate changes can cause disproportionate changes in firm value, i.e., see Macaulay 1938, and MacMinn 1994. Doherty and Garven (Doherty and Garven 1995) use the duration concept and show that insurance firms have not selected capital structures that yield immunization from interest rate changes. Interest rate changes can then cause changes in capital structure, to which the corporation must respond by increasing its equity value. Because an outside equity issue is not feasible, the firm must raise equity internally, i.e., by increasing premiums. As a single factor explanation of insurance cycles, this theory suffers from some of the problems discussed for the mismanagement theory, and does not explain

¹¹See National Insurance Consumer Organization, "The Liability Insurance Crisis", 1986. While it is possible that there may have been some imprudent management of a few insurance companies leading up to and during the liability insurance crisis this explanation as an ongoing explanation of insurance cycles (the less severe form of crisis) over long periods of time in a competitive market structure with active merger and acquisition possibilities is difficult to support. Accordingly this paper will primarily focus on stronger economic explanations for the crisis in the various liability lines of insurance. Mismanagement is not restricted to crisis periods to the extent that it is significant. It may just become more apparent during a crisis when weaknesses are exposed. In that sense, then, this part of the theory fits into the shock theory since the crisis provides the shock that exposed the management insufficiency. Additionally, we found no evidence for or against the "greed theory" in the literature, and so we supply some empirical evidence on this issue in a subsequent section.

¹²In competitive or contestable markets, such premium increases would not be feasible, e.g., see (Witt and Aird 1992)

why the extreme in the cycle (the crisis) occurred in the liability lines of insurance rather than the more interest sensitive life and annuity lines of insurance.

Under-Pricing. Insurance markets are sometimes characterized as having soft or hard markets. In a soft market prices are low, and there may be some under-pricing of insurance products (in order to keep business or retain market share) that contributes to a subsequent crisis when the cycle changes. Harrington and Danzon (Harrington and Danzon 1994) propose this approach using differential expectations and excessive risk taking arguments.

Comments on the Literature

The financial constraint thread of the literature in both the loss shock and interest rate change theories represents an innovative approach, however, from a purist's theoretical, viewpoint, is very limited because the financial constraint is *imposed ad hoc* and therefore supply produced is also not endogenously determined. Fragments of theory that exist do motivate the constraint, but the constraint is not endogenous. This leaves us with essentially a proof by assumption, and this method of explaining the crisis or cycles in general is not satisfactory. It should also be noted that in the financial constraint theory, expectations of the insurer do not have to change since a large loss or interest rate change suffices to change the capital structure and hence triggers the cycle change or crisis. If not all large loss events are associated with changes in expectations then this suggests that it would be possible to test the loss-shock or financial constraint theory by examining empirically if most large loss events for the industry

(e.g., hurricanes, earthquakes, the tobacco liability settlement, the asbestosis settlements etc.) are associated with a turn in the insurance cycle or if such changes in the cycles occur not from such loss experiences (affecting surplus capacity) but rather from events causing changed expectations of future loss. Such an empirical test is only tangential to the scope of the current paper, but would be a fruitful topic for further research.

A more general theory that generates the behavior implied by the constraint is needed. The basis for such a theory is introduced in the next section. It contains the pertinent economic elements of the loss shock and interest rate change theories and the under-pricing theory and does so in an endogenous (rather than *ad-hoc*) fashion. The model also includes a derivation of demand side of the market (previously ignored) and extends the expectations in the interest rate theory to include other expectation parameters on both sides of the market.

THE LIABILITY INSURANCE MARKET

In this section, we provide the seeds of an endogenous economic synthesis. The insurance market is viewed simply as a market for risk sharing among risk averse agents. The model constructed here contains elements of each argument in the consensus. A general version of the model is used to motivate the loss shock and to examine the impact that the shock has on supply. The loss shock reduces the surplus the insurance company has available to ensure the credibility of its contracts. Since the size of the surplus affects supply, the same variable may be used to motivate and explain under-pricing. Equivalently, soft (hard) markets and cycles can be explained using the

relative size of the surplus in our formulation. The insurer's (and insured's) assessment of future interest rates and other quantitative variables that can effect expectation changes on the part of the insurer or insured also impact the supply and demand. To make the theoretical arguments concrete, in part of the analysis, the standard constant absolute risk aversion and normal distribution assumptions are made to allow an explicit derivation of both the supply and demand functions. To make the theory clear in a visual sense, we use the power of electronic publishing to actually animate these behavioral functions using historical data. As can be seen visually in the animations (and equations) the changing expectations of the insurer and insured provide a sufficient motivation for a cycle or even a crisis. By examining the electronic animation (see Figures 1-3) one can observe the development of a crisis as it occurs (diverging supply and demand functions as it develops dynamically).

Consider a simple financial model of an insurance market. Suppose that losses are bundled as standard exposure units and that an insurance policy is a contract on one standard exposure unit. Also suppose that each exposure unit is identically and independently distributed.¹³ Finally, assume that the market is perfectly competitive so that no single market participant has an ability to control the insurance premium. While these are strong assumptions, they still do allow a portrayal of equilibria in the insurance market that are consistent with

¹³ This IID assumption would have to be changed if one wished to accommodate adverse selection theory. We do not do this here in the interest of simplicity of presentation. Moreover, the current development is already sufficiently complex that we did not wish to lose the visual verification of the theory (the animations showing how prices determined by the intersection of the supply and demand curves) that expectation changes can cause cycles and even crises by unduly detailed refinements. Refinements and detailed improvements of each part of our analysis can be the subject of subsequent papers after the general formulation is understood.

the existence of cycles and of a crisis. Those equilibria are considered in the next section.

Here we consider the determinants of supply and demand and the associated comparative statics in a setting characterized by risk averse agents as both buyers and sellers of insurance. This is a departure from much of the insurance crisis literature where the risk neutrality assumption has played such a prominent role.¹⁴ The risk neutrality assumption, however, is flawed¹⁵ and does not provide the power necessary to explain the cycles or crisis. The risk neutrality assumption is replaced here with a risk averse assumption that allows a much richer description of the supply and demand functions.

The Supply of Insurance Contracts

The supply function for insurance policies supplied by an insurer is a behavioral function that provides the number of contracts that the insurance firm is willing to sell at each possible premium. The

¹⁴ Berger and Cummins (Berger and Cummins 1992) is an exception; they use an increase in insurer risk aversion to generate a simultaneous increase in premiums and a reduction in coverage limits.

¹⁵ The standard argument in support of this assumption is that portfolios can be sufficiently well diversified that the firm cannot create value through diversification and that this implies that firms may be assumed to maximize expected value. The flaw in the argument is that the risk averse behavior that motivates diversification yields stock prices that are risk adjusted. Hence, while the maximization of current shareholder value is appropriate, the maximization of expected value is not! The risk averse behavior is aggregated and embedded in stock prices; it is not embedded in the probabilities. It is possible to work with a probability measure that is derived from the stock prices, but that is not done in the literature. Rather than attempting to derive the appropriate probability distribution here, we chose to work with the more primitive risk averse behavior. There is a second problem with the diversification assumption. This problem is inherent in the notion of diversification. Suppose the returns of one company are positively related to economic risk while the returns of a second are negatively related to economic risk. A risk averse agent then has an incentive to diversify by buying shares in both companies. This process reduces the risk faced by the agent. Now consider the introduction of an insurance company. The insurance company specializes in bundling risks, but these risks are accidental or pure risks and the factors that generate the accident risks are different from those that affect the economic risks. An agent with shares in an insurance company still has an incentive to diversify economic risks but that will not eliminate the accident risks. If the accident risks can be diversified then the firm's objective becomes

following notation is used in the development of the insurance supply function:

- i insurance premium per policy
- n number of policies
- λ random loss on a standard exposure unit
- S company surplus
- r interest rate
- π insurance company income, i.e.,

$$\Pi = (i n + S) (1 + r) - n \lambda$$
- u utility function, $u' > 0$, $u'' < 0$.

The surplus here is an amount carried forward by the company from period to period to ensure the payment of losses in a random environment. It is a stock variable that is affected by loss shocks.

The insurance company is modeled here as a risk averse agent.¹⁶ That agent, (equivalently company decision maker), selects the number of policies to sell to maximize the expected utility of company income. Letting F denote the distribution function, and A denote the support of

the maximization of current shareholder value; if the accident risks cannot be well diversified then management will behave in a risk averse manner.

¹⁶ The only necessity here is that decisions be made as if they were being made by a risk averse agent. Such behavior is apparent if there is a risk averse decision maker in charge of making trade-offs, or if the exhibited insurance company behavior satisfies Von-Neumann and Morgenstern axioms of rational decision making. Since very many insurance companies in the US are either closely held stock companies or are mutual companies essentially controlled by their managers, this is not a bad assumption. In the case of mutual insurers, the organizational structure gives managers substantial control over decision making, and the managers' natural risk aversion as an employee with non-diversifiable human capital involved in the firm will be unchecked by owners. The owners who might otherwise object to risk averse behavior on the part of the decision makers have little actionable recourse as corporate take overs are impossible and proxy fight to change managerial actions are not often used in mutual insurers. Moreover, the customers, as owners, may actually, in substantial numbers, approve of

the distribution function for the loss severity variable, the insurance company selects the number of policies it supplies to solve the following problem:

$$\text{maximize } \int_{\Lambda} u(\Pi(n)) dF \quad (1)$$

The first order condition for the number of policies is

$$\int_{\Lambda} u'(\Pi(n)) \frac{\partial \Pi}{\partial n} dF = \int_{\Lambda} u'(\Pi(n)) [i(1+r) - 1] dF = 0. \quad (2)$$

Equation (2) implicitly defines the supply function of the firm. If the agent were risk neutral then this first order condition also shows that the competitive insurance premium will be the present value of the expected loss.

Supply Theorem. If the interest rate is fixed and u exhibits decreasing absolute risk aversion, then the company supply function $s(i)$ exists and is increasing as a function of premium.

Proof. Recall that the measure of absolute risk aversion is $a = -u''/u'$. Let the function G be defined as

$$G(n, i) = \int_{\Lambda} u'(\Pi(n)) [i(1+r) - 1] dF$$

Note that

exhibited risk aversion since their role as customers makes them appreciate high likelihood of claims payment and solvency.

$$\frac{\partial G}{\partial n} = \int_{\Lambda} u''(\Pi(n)) [i(1+r) - 1]^2 dF < 0$$

It follows by the Implicit Function Theorem that the function supply function exists and

$$s' = \frac{dn}{di} = - \frac{\frac{\partial G}{\partial i}}{\frac{\partial G}{\partial n}} > 0 \quad (3)$$

The inequality in (3) follows if

$$\begin{aligned} \frac{\partial G}{\partial i} &= \int_{\Lambda} \{u' + u'' n [i(1+r) - 1]\} (1+r) dF \\ &= \int_{\Lambda} u' (1+r) dF + n \int_{\Lambda} u'' [i(1+r) - 1] (1+r) dF \\ &> 0 \end{aligned} \quad (4)$$

The first term on the right hand side of (4) is positive since more is preferred to less, i.e., $u' > 0$. Decreasing absolute risk aversion suffices to show that the second term on the right hand side of (4) is positive; see the appendix for a proof of the last statement. QED

The supply theorem shows that (under the conditions of the theorem) the supply function exists and, in some cases, is increasing. The supply is not, however, necessarily monotone, as a special but important case will show subsequently. The next theorem shows how the company surplus can affect the position of the supply function, thus

relating our model to the loss-shock theories of cycles wherein the affect is through the surplus.

Loss Shock Theorem. A fixed interest rate and decreasing absolute risk aversion suffice to show that the supply function is increasing in the surplus, i.e., less surplus will result in less supply.

Proof. Let the function H be defined as

$$H(n, S) \equiv \int_{\Lambda} u'(\Pi(n)) [i(1+r) - 1] dF$$

It follows that the number of policies supplied by the firm is increasing in the surplus if

$$\frac{dn}{dS} = - \frac{\frac{\partial H}{\partial S}}{\frac{\partial H}{\partial n}} > 0$$

The denominator is negative due to risk aversion. The numerator is positive if the company exhibits decreasing absolute risk aversion.¹⁷

QED

Given a fixed interest rate, decreasing absolute risk aversion by the decision maker suffices to prove that the supply is increasing in the

¹⁷ A sketch of the proof is in the appendix. The result is analytically equivalent to Sandmo's result, (Sandmo 1971), showing that an increase in fixed cost yields a reduction in a competitive firm's output given decreasing absolute risk aversion.

surplus.¹⁸ The result may also hold for a random interest rate but the proof is beyond the scope of this paper. It is possible to interpret a loss shock in this setting as a reduction in surplus. This theorem then implies that supply decreases with a loss shock. Hence, this model does generate a loss shock interpretation for cycles and crises. In addition, since supply depends on the relative size of the surplus, changes in the surplus can be used to explain the phenomena of alternately hard and soft markets, i.e., cycles. However, we address this issue more fully later, and can even use this analysis to examine when cycles turn into crises.

While the loss shock theorem provides a theoretical foundation for the impact of shocks to corporate surplus, this model simultaneously shows how other factors impact the supply of insurance contracts. To go further in our analysis, and to focus on the other factors, we shall make distributional assumptions within the model that allows an explicit derivation of the supply and subsequently the demand.¹⁹ Suppose that Π is normally distributed with mean μ_{Π} and standard deviation σ_{Π} and that the management of the insurance company can be characterized as making policy decisions in a manner which is consistent with risk averse behavior²⁰ with a utility exhibiting constant absolute risk aversion, i.e., $u(\pi) = -\exp(-a\pi)$ where a is a positive constant that denotes the measure of absolute risk aversion. Since

¹⁸ The result may also hold for a random interest rate but the proof is beyond the scope of this paper.

¹⁹ Other distributional assumptions could be made, and the various functions determined numerically, however this does not shed any additional theoretical insights, and hence is not done here. The parsimony of having a closed form solution you can examine and graph easily makes the subsequent analysis more understandable to the reader while retaining all the economic intuition.

²⁰ Behavior that is consistent with risk averse behavior can occur even when the decision maker is assumed to be risk neutral provided that other concave or convex functions are involved in the analysis.

management makes decisions to maximize expected utility, the objective function can also be expressed as²¹

$$\mu_{\Pi} - \frac{1}{2} a \sigma_{\Pi}^2.$$

The second term is the risk premium. It is possible to restate the objective function in equivalent form in terms of the market variables defining Π as

$$\mu_{\Pi} - \frac{1}{2} a \sigma_{\Pi}^2 = (1 + \mu_r) (i n + S) - \mu_1 n - \frac{1}{2} a \left(\sigma_1^2 + i^2 \sigma_r^2 + S^2 \sigma_r^2 \right) n^2 \quad (5)$$

Maximizing the objective function with respect to the number of insurance contracts yields

$$(1 + \mu_r) i - \mu_1 - a \left(\sigma_1^2 + i^2 \sigma_r^2 \right) n = 0 \quad (6)$$

It follows that the supply function is $s(i; \mu, \sigma)$, where²²

$$n = s(i; \mu, \sigma) = \frac{(1 + \mu_r) i - \mu_1}{a \left(\sigma_1^2 + i^2 \sigma_r^2 \right)} \quad (7)$$

²¹In general if $u(x) = -\exp(-a x)$, then $Eu(\Pi) = -M(-a)$, where M is the moment generating function of Π . Note that $M(t) = E(\exp(t \Pi))$ and so $E(-\exp(-a \Pi)) = -M(-a)$. For $\Pi \sim N(\mu_{\Pi}, \sigma_{\Pi}^2)$, $\mu(t) = \exp(\mu_{\Pi} t + \frac{1}{2} \sigma_{\Pi}^2 t^2)$. Therefore,

$E(u(\Pi)) = -E[\exp(-a \Pi)] = -\exp[-a(\mu_{\Pi} - \frac{1}{2} a \sigma_{\Pi}^2)]$

Where $\mu \equiv (\mu_\lambda, \mu_r)$, and $\sigma \equiv (\sigma_\lambda, \sigma_r)$. Note that the price intercept on the supply function is i^0 where

$$i^0 = \frac{\mu_l}{(1 + \mu_r)}$$

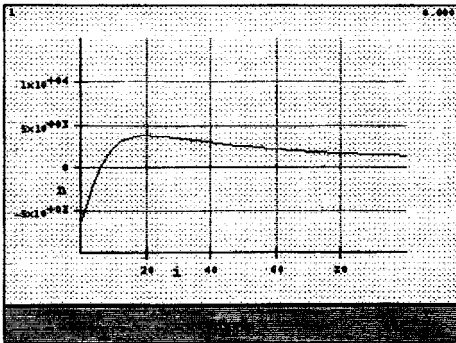
This simply says that the insurance company is only willing to sell contracts at premiums that exceed the present value of the expected losses.

The form of the supply function is quite sensitive to the mean and standard deviation parameters (μ, σ) . Figure one shows the shape of the supply function for a particular choice of mean and standard deviation parameters taken from estimates of historic values. For some parameter choices the supply may actually be backward bending as shown in figure one. This backward bend in supply is not crucial to (or even involved in) any of the subsequent analysis but it may require some explanation. The explanation for the backward bending section is contained in the first order condition, i.e., equation (2). An increase in the premium increases the expected investment income at the margin but also increases the investment income risk and the only way to control the risk here is to reduce the number of policies sold; hence, *ceteris paribus*, the supply bends back for sufficiently large premium levels. The animation embedded in figure one shows how the supply is affected by an increase in the mean and standard deviation of the loss,

²² Note that the supply is linear if the interest rate is fixed.

i.e., the parameters μ_1 and σ_1^2 representing ex-ante expectations of loss and risk of a loss as determined by the insurer.

Figure 1: Supply Function of the Insurer²³



This animation shows that when the insurer experiences events which cause it to change its ex-ante expectation of future losses or risk upward, it will respond by limiting the number of policies written and increasing the premiums for those it does write. Conversely, just the opposite occurs when the insurer perceives that expected losses or risk is decreasing. Then availability increases and required premiums fall. Taken together, these changing expectations can cause cycles (or, as we shall see when demand is also considered) even crises. It is also interesting to note that Figure 1 and the associated animation also show that the supply becomes inelastic as the underwriting loss risk becomes indefinitely large; equivalently,

²³This animation is a QuickTime movie that can also be accessed at <http://kiwiclub.bus.utexas.edu/crisis/supply.mov>.

$$\left| \frac{\partial s}{\partial i} \right| \rightarrow 0 \text{ as } \sigma_l^2 \rightarrow \infty$$

since

$$\frac{\partial s}{\partial i} = \frac{(1 + \mu_r)}{a(\sigma_l^2 + i^2 \sigma_r^2)} - \frac{2 a i \sigma_r^2 ((1 + \mu_r) i - \mu_l)}{(a(\sigma_l^2 + i^2 \sigma_r^2))^2}$$

Alternatively, an increase in loss risk yields a reduction in supply since

$$\frac{\partial s}{\partial \sigma_l^2} = - \frac{n}{i^2 \sigma_r^2 + \sigma_l^2} < 0 \quad (8)$$

Since these are expectation of risk, a sequence of large tort liability claim settlements could precipitate an increased perception of liability risk (i.e., σ_l^2 increases) resulting in a more inelastic supply of insurance from the insurer. An increase in interest rate risk also limits the number of contracts the company is willing to supply since

$$\frac{\partial s}{\partial \sigma_r^2} = - \frac{i^2 n}{i^2 \sigma_r^2 + \sigma_l^2} < 0 \quad (9)$$

this can correspond to the interest rate shock theory. Thus, our economic theory explains such premium increases and availability contractions as rational economic reaction on the part of the insurer, and not merely "over reaction", "greed" or "irrationality".

Finally, comparative statics also show that the premium increases given an increase in the expected unit loss, and also that an increase in the expected interest rate may decrease the premium. These observations are due to the following derivative property:

$$\frac{\partial s}{\partial \mu_1} = -\frac{1}{i^2 \sigma_r^2 + \sigma_l^2} < 0 \quad (10)$$

$$\frac{\partial s}{\partial \mu_r} = \frac{i}{i^2 \sigma_r^2 + \sigma_l^2} > 0 \quad (11)$$

This in turn shows the role of the "interest rate" theories within our more general endogenous economic model.

The Demand for Insurance Contracts

We now depart from all of the extant literature on insurance cycles and crises by considering the demand side of the market. This side of the market has been ignored previously, however no market exists without both sides, and both sides are needed for markets to clear and prices to be set. Without considering demand and well as supply, any explanation of cycles must be considered as only partial.

The demand curve presented by insurance buyers is a behavioral function that provides the number of contracts that the insured firm is willing to buy at each possible premium. The following additional notation is used in the development of the insurance demand function.

- P random product price
- q units of output
- c(q) production cost

N number of insurable exposure units
commercial firm income, i.e.,

$$\Gamma \equiv P q - c(q) - (1 + r) i n - (N - n) \lambda$$

The commercial firm who is buying the insurance is modeled here as risk averse agent (see footnotes 13 and 14 which are equally applicable here). That agent or firm selects the number of policies to buy to maximize the expected utility of firm's income. Thus, the firm selects the number of insurance policies to purchase in such a manner as to solve the following problem:

$$\text{maximize } \int_{\Lambda} u(\Gamma(n, q)) dF \quad (12)$$

The first order condition for the number of policies is

$$\int_{\Lambda} u'(\Gamma) \frac{\partial \Gamma}{\partial n} dF = \int_{\Lambda} u'(\Gamma) [1 - i(1+r)] dF = 0 \quad (13)$$

Equation (13) implicitly defines the demand function of the firm buying the insurance. If the agent representing the firm is risk neutral, then this first order condition also shows that the competitive insurance premium will be the present value of the expected loss.

Demand Theorem. If the insurance purchaser (firm) exhibits decreasing absolute risk aversion, and the interest rate is fixed, then the firm demand function $d(i)$ exists and is decreasing.

Proof. Let the function H be defined as

$$H(i, n) \equiv \int_{\Lambda} u'(\Gamma) [1 - i(1+r)] dF$$

Note that

$$\frac{\partial H}{\partial n} \equiv \int_{\Lambda} u''(\Gamma) [1 - i(1+r)]^2 dF < 0$$

It follows by the Implicit Function Theorem that the demand supply function exists and

$$d' = \frac{dn}{di} = - \frac{\frac{\partial H}{\partial i}}{\frac{\partial H}{\partial n}} < 0 \quad (14)$$

The inequality in (14) follows if

$$\begin{aligned} \frac{\partial H}{\partial i} &= \int_{\Lambda} \{-u' - u'' n [1 - i(1+r)]\} (1+r) dF \\ &= - \int_{\Lambda} u' (1+r) dF - n \int_{\Lambda} u'' [1 - i(1+r)] (1+r) dF \\ &< 0 \end{aligned} \quad (15)$$

The first term on the right hand side of (15) is negative since more is preferred to less, i.e., $u' > 0$. Decreasing absolute risk aversion suffices to show that the second term on the right hand side of (15) is negative; see the appendix for a proof of the last statement. QED

The demand theorem shows that the demand function exists and, under the assumptions of the theorem, is decreasing. The demand

function, however, is not necessarily monotone, as a special case will show subsequently.

As in the previous section, for concreteness of presentation we will consider a special case of the model that allows an explicit derivation of the demand. Suppose firms select the number of policies to buy to maximize the expected utility of the company income. Suppose further that Γ is normally distributed with mean

$$\mu_{\Gamma} = \mu_p q - c(q) - (1 + \mu_r) i n - (N - n) \mu_l$$

and variance

$$\sigma_{\Gamma}^2 = \sigma_p^2 q^2 + (i n)^2 \sigma_r^2 + (N - n)^2 \sigma_l^2$$

and that the management of the company can be characterized as having constant absolute risk aversion with risk aversion parameter γ . If management makes decisions to maximize expected utility then, as before, the objective function can also be expressed as

$$\begin{aligned} & \text{maximize } \mu_{\Gamma} - \frac{1}{2} \gamma \sigma_{\Gamma}^2 \\ & \text{subject to } n \leq N \end{aligned} \tag{16}$$

If the constraint is not binding then the first order condition for the quantity of insurance that will be bought is

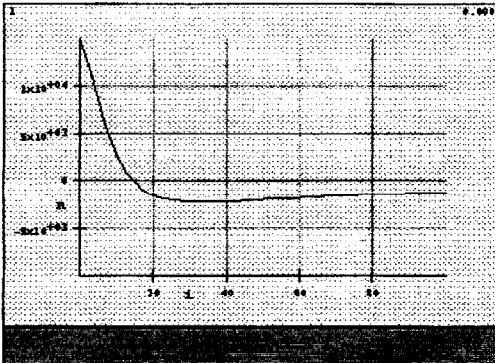
$$-(1 + \mu_r) i + \mu_l - \gamma (i^2 n \sigma_r^2 - (N - n) \sigma_l^2) = 0 \tag{17}$$

and so the demand function is $d(i; \mu, \sigma)$ where

$$n = d(i; \mu, \sigma) = \max \left\{ N, \frac{N \gamma \sigma_l^2 - \left[(1 + \mu_r) i - \mu_l \right]}{\gamma (i^2 \sigma_r^2 + \sigma_l^2)} \right\} \quad (18)$$

Note that if the interest rate were safe (non-random or fixed) and the premium were equal to the present value of the expected unit losses then the company covers all the insurable losses i.e., fully insures their exposures. This is consistent with known results in insurance economics, but we arrive at this result in a different manner. Figure 2 shows the shape of the demand function, when the constraint relating to the maximum number of exposure units, N , is not binding, for a particular choice of mean and standard deviation parameters.

Figure 2: Demand²⁴



Like Figure 1, Figure 2 also contains an animation and comparative static, for the change in demand given an increase in the mean and standard deviation of the loss. Note that, *ceteris paribus*, the demand becomes inelastic at the number of insurable losses, i.e., N , as the loss risk increases; equivalently,

$$\left| \frac{\partial d}{\partial i} \right| \rightarrow 0 \text{ as } \sigma_l^2 \rightarrow \infty \quad (19)$$

since

$$\begin{aligned} \frac{\partial d}{\partial i} &= \frac{\gamma (i^2 \sigma_r^2 + \sigma_l^2) \left(- (1 + \mu_r) \right)}{\left(\gamma (i^2 \sigma_r^2 + \sigma_l^2) \right)^2} \\ &\quad - \frac{\left(N \gamma \sigma_l^2 - \left[(1 + \mu_r) i - \mu_l \right] \right) 2 \gamma i \sigma_r^2}{\left(\gamma (i^2 \sigma_r^2 + \sigma_l^2) \right)^2} \\ &= - \frac{(1 + \mu_r)}{\gamma (i^2 \sigma_r^2 + \sigma_l^2)} - n \frac{2 \gamma i \sigma_r^2}{\gamma (i^2 \sigma_r^2 + \sigma_l^2)} \end{aligned}$$

It, and a similar comparative static for the expected unit loss, both show increases in the number of policies demanded with increases in the mean and standard deviation, i.e.,

$$\frac{\partial d}{\partial \mu_l} = \frac{1}{\gamma (i^2 \sigma_r^2 + \sigma_l^2)} > 0; \quad \frac{\partial d}{\partial \sigma_l^2} = \frac{N - n}{i^2 \sigma_r^2 + \sigma_l^2} \geq 0 \quad (20)$$

²⁴This animation is a QuickTime movie that can also be accessed at <http://kiwiclub.bus.utexas.edu/crisis/demand.mov>.

Comparative statics for the change in demand given an increase in the mean interest rate and the interest rate risk both show a decrease in the number of policies demanded with increases in the mean and standard deviation, i.e.,

$$\frac{\partial d}{\partial \mu_r} = -\frac{i}{\gamma(i^2\sigma_r^2 + \sigma_i^2)} < 0; \quad \frac{\partial d}{\partial \sigma_r^2} = -\frac{i^2 n}{i^2\sigma_r^2 + \sigma_i^2} < 0 \quad (21)$$

MARKET EQUILIBRIA AND PRICES

A crisis exists in a market when there is a radical change in market conditions. The market conditions are reflected in supply and demand. Based on the behavioral functions derived in the last section, another hypothesis about the causes of the liability crisis is offered here which incorporates (and is consistent with) other "single factor" theories previously explicated in the literature. The hypothesis presented here is that the liability crisis was caused by changes in the expectations, i.e., (μ, σ) , of insurers that adversely affected supply by shifting the supply curve, and that the corresponding changes in the expectations of the commercial buyers simultaneously shifted demand curve in a manner that amplified rather than dampened the premium changes. Such changes can also explain cycles (illustrated by simply reversing the animation in Figure3).

It is important to note that these expectations are based on the anticipated distributions of the losses and interest rates. Hence, it is important to consider the construction of these distributions and the consequent structure of supply and demand.

Since losses and investment income are unknown when insurance contracts are underwritten, firms must use *ex ante* estimates of the costs and benefits. To understand how firms change their expectations, the process of forming expectations and the factors that affect those expectations need to be assessed. The two basic elements that influence the formation of expectations are past experience and estimated future benefits and costs by line of business. Past experience can serve as a starting point to predict future losses and investment income (cf., Brockett and Witt 1982). Past experience alone, however, can yield lags in adjusting expectations.²⁵ While that experience is important, it cannot be the only method used in forming expectations because it is based on a history of economic, legal, and social conditions which may be expected to change. A change in legal precedent will not be reflected for some time in such a history but can have an immediate impact on the loss distributions following year. Such a change causes a revision in the anticipated distributions by forwarding looking market agents. Therefore, both past and anticipated experiences have to be evaluated by firms in forming expectations about the future.²⁶

Firms will change their behavior if one or more of the factors influencing their expectations change. Because we have assumed risk averse decision makers, not only the means but also the variances of losses and interest rates are the important factors influencing premiums and the number of policies sold. Firms must evaluate all the factors that affect future liability insurance benefits and costs based on the

²⁵See Cummins and Outreville 1987; Harrington 1988. One gains an even greater respect for their result when animating the demand and supply functions (as in Figure 3) because it is difficult to construct equilibria market prices in the pre-crisis years using historical data for those years.

past experience and futures prospects, and combine those to form their expectations about future costs and benefits. The behavior of firms is based on the combined effect of these individual expectations, as exhibited by their supply, and demand functions (which are functions of (μ, σ^2) as described previously).

To see the impact of changing expectations in the insurance market, consider the aggregated behavioral functions, i.e., the industry wide supply and demand functions. Let $s_f(i, \mu, \sigma)$ denote the supply of insurance firm f and let N_s be the number of insurers, i.e., sellers. Then the market supply is defined as

$$s(i, \mu, \sigma) = \sum_{f=1}^{N_s} s_f(i, \mu, \sigma) \quad (22)$$

Similarly, let $d_f(i, \mu, \sigma)$ denote the demand of insurance buyer or corporation f and let N_b be the number of commercial buyers. Then the market demand is defined as

$$d(i, \mu, \sigma) = \sum_{f=1}^{N_b} d_f(i, \mu, \sigma) \quad (23)$$

Both aggregated behavioral functions depend on the expectations (μ, σ) , and jointly determine the equilibrium premium in the market.²⁷

²⁶Most state rate regulatory statutes recognize this fact; see (Witt 1973; Witt 1973; Witt and Urrutia 1983, Brockett and Witt 1982)

²⁷ One does not need to assume that buyers and sellers share common expectations about the means and variances of the various market parameters and loss parameters. Indeed, cyclic behavior can be created more easily in this latter situation. We shall see that such cycles, and even market failure (crisis), can

The equilibrium condition, i.e., supply equal demand, yields the relation $s(i; \mu, \sigma) = d(i; \mu, \sigma)$ or equivalently, with identical firms on either side of the market, the relation²⁸

$$\frac{(1 + \mu_r)i - \mu_l}{a(i^2 \sigma_r^2 + \sigma_l^2)} N_s = \frac{N \gamma \sigma_l^2 - [(1 + \mu_r)i - \mu_l]}{\gamma (i^2 \sigma_r^2 + \sigma_l^2)} N_b$$

Direct calculation shows that the equilibrium premium can be expressed as a function $f(\mu, \sigma)$, and that the form of this function is as follows

$$i = f(\mu, \sigma) \equiv \frac{\mu_l}{1 + \mu_r} + \frac{\gamma N \sigma_l^2}{1 + \mu_r} \frac{a N_b}{a N_b + \gamma N_s} \quad (24)$$

Hence, the equilibrium insurance premium is the present value of the expected loss, plus a risk premium that depends on the risk aversion characteristics of the buyer and seller. It is interesting to note that the equilibrium premium is not affected by changes in interest rate risk. While it does affect supply and demand, that affect is symmetric.²⁹ The risk premium depends positively on risk aversion, loss risk, and the number of agents on each side of the market.

occur even when there is a consensus of expectations about parameters between buyers and sellers, a harder case scenario.

²⁸ Recall that the N in the demand is the number of insurable risks per firm; it is not the same as N_b which represents the number of buyers.

²⁹ This result follows from using the same expectations for buyers and sellers, as does the closed form solution for the premium here. It is also interesting to note that this analysis suggests that the impact due to adverse selection is not clear. If due to adverse selection buyers exit the market, and by their exiting, there is an increase in the expected loss for the remaining market pool, but their exiting and leaves the variance of the loss the same, then, although there is an increase in the present value of the loss, there is a reduction in the risk premium. The examination of adverse selection effects in this endogenous economic framework warrants further research.

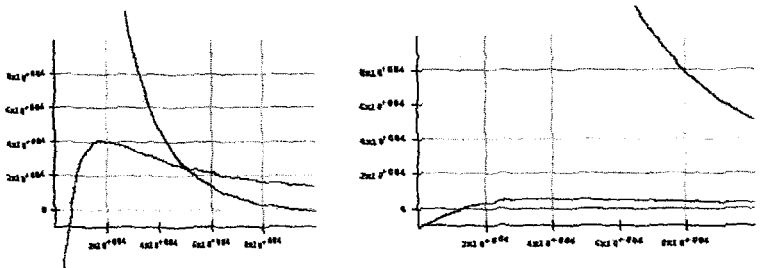
As one would expect, equation (24) predicts an increase in premiums, when the mean and variance of losses increase and the mean interest rate decreases. The hypothesis here is that changing expectations that adversely affected the structure of demand and supply caused the crisis and can cause cycles.

As an illustration, an animation of the crisis is portrayed in the next figure. The animation cannot completely capture the theory because it is based on historical information. To the extent that anticipations about the movement in the parameters were correct, however, they are captured here. In constructing the animation, the unit expectations for the pre-crisis years in the data were used (i.e., the parameters were "normed" on pre-crisis values), and then the parameters were changed by the multiple indicated by the data.³⁰ The functions in the figure have not been changed, i.e., the supply and demand shown are aggregated versions of the supply and demand shown in figures 1 and 2. Figure 3 and animation assume the same expectations (μ , σ^2) on both sides of the market. The figure shows the first and last step in a sequence of changing expectations; in each step, the change, in means and variances, alters the structure of demand and supply. The animation shows how supply and demand changes sequentially as all the expectations, except the mean interest rate, increase; the mean interest is decreased in the animation.

Supply is decreasing in all expectation parameters except the mean interest rate as shown in (8) through (11) while demand is increasing in the loss expectations as shown in (20) and decreasing in the investment expectations as shown in (21). The combined effects of the expectation changes move the premium higher, cause the number of contracts traded

to approach zero, and remain there. The animation, based on the data, is consistent with market failure. As expectations change downward, just the opposite occurs, and a cycle is obtained. This is also illustrated in the animation.

Figure 3: Equilibria³¹



The animation provides a synthesis and generalization of several of the theories, e.g., tort changes risk perception changes and underwriting changes and is consistent with the existence of cycles and a crisis. The figure shows that all the parameters can play a role in generating a crisis and it implies that no one parameter has to change as dramatically as would be necessary in any single factor explanation in order to generate cycles or a crisis.

³⁰ The market data and derived multiples are specified in the appendix.

³¹ This animation can also be accessed on the web at <http://kiwiclub.bus.utexas.edu/crisis/crisis.html>.

EMPIRICAL EVIDENCE³²

Although the theoretical explication of the previous sections can stand on its own, it is worthwhile to see if the implications of such a model are inconsistent with empirical data. In this section, we present empirical evidence that supports some of the most basic implications of the previously explicated theoretical model. In particular, several empirical hypotheses are examined here. First, the economic model previously exposed suggests that the equilibrium premium, when determined as an endogenous variable, should be a *positive* function of the expected value and variance of losses as is the demand for insurance. Accordingly, the premium income, which is the premium times the demand, should also be positive increasing function of the mean loss. We test if the empirical data support such a prediction. Second, we examine the behavior of those variables that are directly responsible for the change in premiums. Because the theoretical model suggests an inverse relation between equilibrium premium and investment returns, we also examine whether the mean of investment returns for the insurers indeed decrease during the period of insurance crisis to be consistent with the sharp increase in premiums observed in that period. Because the model predicts that the equilibrium premium is not affected by changes in interest rate risk, we also test whether the standard deviation of investment returns is related to premiums. Finally, we provide additional empirical evidence that sheds lights on the greed and mismanagement hypothesis. It should be noted that the purpose of this section is to provide some empirical verification of certain of the implications of theoretical model, and is not intended as

³² If the reader is concerned only with the theory, then he can stop here. The expenses have been separated from the losses in this section. Changing legal

a full scaled exhaustive analysis of all contingencies such an analysis would require another paper). One desire of this empirical section is to stimulate such a more extensive examination of the empirical aspects of the model.

Empirical Evidence From Cross-Sectional Data

Using cross-sectional regression analysis, we examine the first hypothesis that relates the equilibrium premium to the mean and variance of losses here. The data used in this subsection were obtained from A. M. Best's Property/Liability Tapes. The initial sample consists of the top 100 groups and single unaffiliated companies. Due to missing data for some of the entities, the final sample size was restricted to 65 groups and unaffiliated companies.

To test the first hypothesis, two different approaches might be used. We might use the premium, that is the price aspect of the premium income, as the dependent variable in a regression analysis and then relate it to other exogenous variables such as mean and variance of losses as the independent variables in the regression analysis. The problem with this approach is that, unlike premium income, the premium itself is not directly observable in the collected data set available for analysis. Prior studies, e.g., (Cummins and Danzon 1997), have utilized a proxy for the premium in empirical analyses that normalizes the premium income by losses, however this gives a dimensionless quantity (the reciprocal of the incurred loss ratio) and not a measure of price or premium.

This study adopts a second approach that can directly test the implication of our theoretical model. We test the behavior of the

standards do motivate the randomness in expenses.

premium income because both price and quantity effects contributed to the insurance crisis as demonstrated in the theoretical analysis. Thus, examination of the premium income is a more general test of the theoretical model than would be obtained using premium income divided by losses.

Let the premium income be denoted by $I(\mu, \sigma) = i(\mu, \sigma) d(\mu, \sigma)$, where i is the premium on each contract, d is the number of contracts demanded, μ is the expected loss and σ is the standard deviation of the loss. The comparative static for the premium income is:

$$\begin{aligned}\frac{\partial I}{\partial \mu} &= \frac{\partial i}{\partial \mu} d + i \left(\frac{\partial d}{\partial i} \frac{\partial i}{\partial \mu} + \frac{\partial d}{\partial \mu} \right) \\ &= \frac{\partial i}{\partial \mu} \left(d + i \frac{\partial d}{\partial i} \right) + i \frac{\partial d}{\partial \mu} \\ &= \frac{\partial i}{\partial \mu} \frac{1}{d} (1 - \varepsilon) + i \frac{\partial d}{\partial \mu} \\ &> 0\end{aligned}$$

where ε is the elasticity of demand. Recall that we have shown that the premium i is increasing in the mean loss and demand is increasing in the mean loss. Therefore, this analysis shows that an inelastic demand suffices to show that the premium income is increasing in the mean loss.

Similarly, we derive the relationship between the premium income (1) and variance of losses. Following the above analysis, we differentiate premium income with respect to the standard deviation of losses. Using the results in equations (21) and (24), we can obtain a positive relationship between premium income and standard deviation of losses.

We have shown that the premium income is increasing in the mean and standard deviation (or variance) of loss and demand is increasing in the mean and standard deviation (or variance) of losses given an inelastic demand. In the empirical analysis, we consider if the mean and variance of the losses, MLOS, VLOS, and expense, MEXP, and VEXP, are positively related to the premium that is used as the dependent variable. Specifically, the following regression model that can be derived from theoretical model is used as follows:

$$\text{MNPW} = f(\text{MLOS}, \text{VLOS}, \text{MEXP}, \text{VEXP}, \text{PS}, \text{SIZE}, \text{RE}, \text{LIQ}, \text{ORG})$$

where

MNPW	the change in the mean or average growth rates of net premiums written between the 1980-1983 period and the 1983-1986 period
MLOS	the change in the mean or average growth rates of the losses between 1980-1983 and 1983-1986
VLOS	the change in variance of growth rates of losses between 1980-1983 and 1983-1986
MEXP	the change in the mean or average growth rates of expenses between 1980-1983 and 1983-1986 ³³

³³ Expenses include loss adjustment expenses and total underwriting expenses. We combine all of the expenses into one variable to avoid multicollinearity problem. Furthermore, the definition of expenses variable is the same as our theoretical model.

VEXP	the change in variance of growth rates of expenses between 1980-1983 and 1983-1986
PS	the premium to surplus ratio in 1986
SIZE	the natural logarithm of total assets of the firm in 1986
RE	net reinsurance ceded divided by direct premiums written in 1986
LIQ	cash plus government bonds over admitted assets in 1986
ORG	a dummy (0, 1) variable denoting the organization structure of the firm; 0 for stock companies and 1 for mutual companies

The computation of the dependent and the four exogenous variables deserves further explanation. To illustrate how to compute MLOS and VLOS, first we calculate the growth rate of losses for each year between 1980 and 1986. Second, the six growth rates for 1980-1986 were then partitioned into two periods. The mean (variance) of the three growth rates from 1980 to 1983 was used as a proxy to represent the expectation about the mean (uncertainty) of the losses during this non-crisis period. Similarly, the mean (variance) of the growth rates from liability crisis period, 1983 to 1986, was used as a proxy for the expectation about the mean (uncertainty) of the losses. Finally, the difference between the two means (variances) was calculated to obtain MLOS (VLOS). We undertake a similar procedure for MNPW, MEXP and VEXP.

Table 1 reports the results of three regression analyses. In Model 1, MLOS, MEXP, VEXP are positive and significant at the 1% level. This

result suggests that premiums were positively related to the expected value of losses (MLOS), the expected value of expenses (MEXP), and the variance of the expenses (VEXP).

The variance of losses in Model 1 is has the correct positive sign, but is not significant. Analysis of the correlation matrix showed that the correlation coefficient between MLOS and VLOS was 47.6% and significant at 0.01% level. This analysis suggests that the non-significance of the losses in model 1 h may be due to a multicollinearity problem.

Table 1 Results of Regressions of Net Premiums Written for the Largest 100 Group Insurers (t-statistics are in parentheses)			
	1	2	3
Intercept	-0.77 (-0.87)	-1.433 (-1.54)	0.424 (10.23) ***
MLOS	0.327 (3.13) ***		
VLOS	0.084 -1.46	0.183 (3.55) ***	0.143 (3.07) ***
MEXP	0.683 (4.89) ***	0.76 (4.70) ***	
VEXP	0.064 (4.68) ***	0.064 (4.34) ***	
MPS	-0.613 (-3.38) ***	-0.524 (-2.72) ***	
MSIZE	0.062 (1.71) *	0.093 (2.51) **	
MRE	0.002	0.002	
	-0.21	-0.18	
MLIQ	-0.356 (-0.91)	-0.246 (-0.59)	
ORG	-0.006 (-0.09)	-0.044 (-0.60)	
R2	59%	51%	12%

In Model 2, MLOS was dropped because of the high degree of correlation between MLOS and VLOS. As expected, the variance of losses (VLOS) in this new model was now found to be positive and significant at 1%, a result consistent with the predictions suggested by our theoretical model. The results for the remaining variables in Model 2 are similar to those in Model 1. One minor difference is that Size variable is significant at 5% level in Model 2 rather than 10% level in Model 1. The R square in Model 2 was 51% and significant at the 1% level.

The coefficient of the premium-to-surplus ratio (PS) is negative and significant at 1% level, implying that premium increases were negatively related to leverage. That is, a firm with high leverage was not able to increase its premiums as much as a firm with low leverage. The coefficient of the size variable (SIZE) was positive and significant at 10% level. This result implies that the larger the company, the higher the premiums the company was able to charge. This is consistent with data envelopment analysis studies which use solvency, return of equity and claims paying ability as the desired outputs of an insurance firm from a financial intermediary perspective (c.f. Brockett, Cooper, Golden and Wang 1998, 1999). The other control variables including the reinsurance variable, liquidity variable, and organization variable were not significant. The measure of model fit, R square, was 59% and significant at the 1 % level.

Since VLOS is significant in Model 2 but not significant in Model 1, and because of colinearity with MLOS, VLOS alone is examined in Model 3 to provide further evidence that VLOS is one of underlying factors that contributed to the commercial insurance liability crisis.

VLOS is significant at 1% in Model 3. Furthermore, VLOS alone can explain 12% of the variation in premiums.

In summary, the increase in premiums can be explained by increases in mean and variance of losses and mean and variance of expenses. These results are consistent with the predictions of the model.

Although the cross-sectional analysis provides many important results, it could not include an assessment of the interest rate factor because all of the firms in the sample basically faced the same interest rates.³⁴ Therefore, in the next subsection a separate time series analysis using industry data is performed to provide some evidence on the impact of interest rates.

Empirical Evidence on the Interest Rate Factor Using Industry Data

This subsection provides some statistics on the growth rates of relevant variables that are directly related to our theoretic model. The use of growth rates contrasts with the various financial ratios utilized in Clarke *et. al.* (1988). Because financial ratios, which include premiums as a denominator, may not explain premium increases, use of the growth rates seems to be more appropriate for our purpose.

Tables 2 and 3 present some statistics describing the performance of the Other Liability Insurance lines, which appear to be most pronounced for the liability crisis. The average growth rates and test statistics for net premiums written, net premiums earned, losses incurred, various expenses, and net investment gain/loss are reported for the pre-crisis and crisis periods of 1979-1983 and 1984-1986 in Table 2 and of 1978-1982 and 1983-1987 in Table 3.

³⁴ It should be noted that the interest rate is one of the factors that determine the premium in our theoretical model.

In Table 2, the three-year time period of 1984-1986 is chosen because this period basically represents the depth of the insurance cycle (i.e., the major portion of the commercial liability insurance crisis). A pre-crisis five-year time period covering 1979-1983 is used as a basis for comparison. Five-year estimates allow comparisons with previous studies such as Clarke *et. al.* (1988). Further, expectations can change quickly, but not overnight. Therefore, for measurement and statistical purposes the averages of three years and five years of data are reported for robustness instead of using one-year data. This longer-time span approach also helps deal with the long-tail characteristic of liability lines where loss development may take place over several years.

Tables 2 and 3 are exactly the same except for the time periods chosen. The three-year period for 1984 through 1986 in Table 2 which was used to capture the crisis years, is extended to a five-year period 1983 through 1987 in Table 3 for statistical purposes. The results from Table 3 will not be discussed here with few exceptions because the results are basically the same or very similar to those in Table 2.

The empirical evidence on the impact of changing expectations of the insurers about future values of losses, expenses and interest rates on prices and premiums are analyzed below. The average growth rate of incurred losses during the crisis period from 1984 through 1986 for Other Liability was 41.1 percent and from 1979 to 1983 was 6.0 percent, as shown in Table 2. These differences in growth rates during these time periods reject the null hypothesis of no difference and appear to support an alternative hypothesis that actuarial and managerial expectations about future losses would have changed in rational profit-seeking insurance firms with reasonable information

systems. The t-statistics in Table 2 shows that the average growth rates of losses incurred were significantly higher during the 1984-1986 crisis period than that of the pre-crisis period for the Other Liability lines. Similar to the findings on losses incurred, growth rates for loss adjustment expenses and other underwriting expenses were significantly higher during the crisis period for the Other Liability lines of insurance. Expectations about expenses tended to change because of the dramatic rise in litigation and legal expenses, especially the legal expense associated with the defense of liability law suits, according to the Insurance services Office (1989).³⁵

One interesting result is that the growth rates for commission and brokerage expenses were significantly higher at a 5 percent level or less during the crisis period. Apparently, the growth in premiums in the primary markets more than offset losses of business to alternative insurance markets.³⁶

The growth rates for the net investment gain or loss ratios are used as proxies for interest rates in Table 2 and 3. The advantage of investment gain or loss ratios over interest rates themselves is that these investment income ratios can better capture the cash-flow characteristics of long tail lines of liability insurance. Specifically, a substantial portion of losses for liability insurance, such as Other Liability, may not have been paid after four or five years. Therefore, investment income is a more important source of income for the long-tail liability insurance lines than for the shorter-tail property

³⁵According to this study, legal defense costs on an accident year basis increased from 9.6 percent of losses in 1978 to 13.9 percent of losses in 1988. This constituted a 45 percent increase in the ratio of legal defense expenses to indemnity costs for all liability lines of insurance. This ratio tripled over the 40 years preceding 1989, which indicated significantly greater growth in defense costs than in loss costs. Insurance Services Office, (1989), p.1.

insurance lines. The growth of average investment gain or loss ratios for Other Liability decreased from 19.66 percent in 1979-1983 to - 9.56 percent during the crisis period (1984-1986). The t-statistics in Table 2 show that the ratios were significantly lower during the crisis period for the Other Liability lines of insurance.

The standard deviation of the growth rate in losses reported in Table 2 was significantly higher during the 1984-1986 time period than the period 1979-1983 for the Other Liability insurance line, implying that higher uncertainty associated with loss adjustment expenses in this period.³⁷ Similarly, the standard deviation of the growth rates for commission and brokerage expenses and other underwriting expenses were significantly higher for Other Liability insurance. These two categories of expenses generated standard deviations of 28.25 and 13.89 percentage points during 1984-1986 as compared to 5.86 and 4.25 percentage points during 1979-1983, respectively.

The standard deviation of the growth rates for the investment gain or loss during the crisis (21.9 percent) was almost double to that in the earlier time period (10.12 percent) for Other Liability in Table 2.

³⁶See Witt and Aird (1992) for a discussion and some empirical evidence on surplus lines markets.

³⁷Changing legal standards, liability rules, and contract interpretations have made it extremely difficult to draft clear and unambiguous insurance contracts which precisely define losses that will be covered in all future states of the world. For example, the measurement and estimation of the real value of losses under prior insurance policies is a major problem in long-tail lines such as medical malpractice, products liability, and pollution liability. The pollution liability exclusion in the current CGL policy reflects this difficulty. The ultimate liability of the insurance industry for asbestos-related losses and hazardous waste cleanup under the Superfund law is unknown and has generated a great deal of uncertainty. In the case of asbestos, the trigger issue of whether liability accrues during an injured party's exposure or at the time of manifestation of the injury has created major uncertainty for many established insurers who covered this product liability risk. In the case of the Superfund law, the doctrine of joint and several liability and conflicting judicial rulings on whether or not the pollution exclusion in most general liability policies will be recognized and honored has created extreme uncertainty and risk for insurance companies in the commercial area. For a more detailed discussion of these issues, see Priest (1987), Clarke *et al.* (1988), Harrington and Litan (1988), Huber (1988), and Lai and Witt (1992). For an insightful analysis of how the redesign of insurance contracts can deal with unstable liability rules, see Doherty (1991).

However, the difference in the standard deviations was not statistically significant, the result is particularly interesting because our theoretical model predicts that the equilibrium premium is not affected by changes in interest rate risk.

	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
Other																
Liability	79-85	-2.58	3.58	-1.53	5.5	5.98	4.41	9.15	3.05	-4.79	5.06	6.75	4.25	20.12	10.12	
	86-86	53.33	34.39	45.38	34.62	41.05	14.58	32.04	12.35	41.85	28.25	22.62	13.88	-15.27	21.19	
Change		55.91	30.81	48.77	29.12	35.1	10.17	22.88	8.7	46.04	22.38	15.05	9.64	-35.35	11.07	
t or F		3.82**	92.27***	3.13**	39.59***	5.25**	10.94**	4.05**	11.63**	3.76**	23.26**	2.48*	10.69**	-2.71*	4.35	

a. t (F) statistics reflect test against null hypothesis of equal means (standard deviations). *** Significant at .01 level; ** at .05 level; * at .10 level.
b. The growth rates of the ratios rather than the amounts of Net Investment Gain/Loss & Other Income are used to obtain t- and F- statistics in this column. The growth rates in the other columns are based on absolute amounts. An example of growth rate is calculated as: (net premium written in 1979 - net premium written in 1978)/net premium written in 1978. Five growth rates can be calculated during the period from 1979 to 1983. The average growth rates and standard deviation are then calculated.
Source: The data for analysis in this table was obtained from various issues of Best Aggregates and Averages, A. M. Best Company.

	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
Other																
Liability	78-82	-0.41	7.17	1.61	9.33	6.08	4.48	8.97	3.51	-1.65	10.75	9.85	5.6	19.4	11.45	
	83-87	35.6	36.45	31.48	31.87	28.53	20.07	23.8	14.25	28.68	27.74	17.48	13.19	-6.69	18.87	
Change		34.01	29.28	29.87	22.54	22.45	15.59	14.85	10.73	30.55	16.95	7.6	7.99	-26.29	7.44	
t or F		2.05	25.87***	2.01	11.66**	2.44*	20.11**	2.26*	16.56**	2.28*	6.81*	1.19	5.53	-2.67**	2.72	

a. t (F) statistics reflect test against null hypothesis of equal means (standard deviations). *** Significant at .01 level; ** at .05 level; * at .10 level.
b. The growth rates of the ratios rather than the amounts of Net Investment Gain/Loss & Other Income are used to obtain t- and F- statistics in this column. The growth rates in the other columns are based on absolute amounts. An example of growth rate is calculated as: (net premium written in 1979 - net premium written in 1978)/net premium written in 1978. Five growth rates can be calculated during the period from 1979 to 1983. The average growth rates and standard deviation are then calculated.
c. Source: The data for analysis in this table was obtained from various issues of Best Aggregates and Averages, A. M. Best Company.

Empirical Evidence on the Greed and Mismanagement Hypothesis

As limited empirical evidence on the greed and mismanagement hypothesis is available in the literature, this subsection provides some empirical evidence on this hypothesis. Table 4 presents statistics

describing the performance of three liability lines and the total property-liability industry during two time periods.³⁸ Other Liability Insurance was selected because, among the commercial lines, it experienced the most severe crisis during the mid 1980's. Homeowners' and Auto Liability insurance were selected as controls for comparison with Other Liability because these lines were relatively unaffected by the crisis, as observed earlier by Clarke *et. al.* (1988).

The overall operating cost ratios shown in Table 4 recognizing all sources of costs and income were higher, although they are not significantly higher, during the 1986-1988 time period than during 1980-1987 time span for Other Liability. The two time periods were chosen for contrast because they basically reflect non-crisis periods following earlier crises. In other words, Table 4 shows that higher operating ratios during the crisis period than that of the pre-crisis period. Higher operating ratios imply low profitability. Thus, the profitability of the Other Liability line would be lower in 1986-1988 than during 1976-1980 (even after the dramatic increases in premiums in 1985 and 1986 were recognized).³⁹ Therefore, the evidence in Table 4 does not support the greed hypothesis.

The commission and brokerage expense ratios that can be partially controlled by insurers were significantly lower among all the lines shown in Table 4 during 1986-1988 than the earlier time period. If the lower commissions and brokerage expense ratios are viewed as partial indicators of efficiency and good management performance, this

³⁸Table 4 is constructed by using a methodology similar to that used by Clarke *et. al.* (1988, Table 3).

³⁹The overall operating ratio is defined as the ratio of total underwriting expenses, incurred losses, and loss adjustment expenses minus net investment gain and other income to premiums earned. Total underwriting expenses are defined to include commissions and related brokerage expenses, dividends paid to

evidence would also seem to be inconsistent with the mismanagement and greed hypothesis suggested by NICO.⁴⁰

It is also interesting to note that the underwriting and investment experience were very different during the two non-crisis periods. Specifically, the loss ratios were significantly higher for All Lines of property and liability insurance, the Auto Liability lines, and Other Liability lines during the 1986-1988 period than during 1976-1980. The average loss adjustment expense ratios were significantly higher for the latest time period for all lines shown in Table 4. The higher loss adjustment ratios reflect the growing significance of defense costs in liability insurance prices, as noted in recent studies by the Insurance Services Office (1989 and 1992). On the other hand, net investment income was significantly higher for all of the insurance line categories shown here. Comparing these two non-crisis periods, it appears that the property-liability industry went through some major structural changes between these periods. Therefore, it is probably not reasonable or fair to attribute the recent liability insurance crisis to mismanagement, after the structural changes and the declining profitability of the liability insurance lines are considered.

policyholders, and other underwriting expenses associated with the development and sale of insurance contracts.

⁴⁰For an in-depth study of property-liability insurance distribution systems, see Cummins and Vanderhei (1979) and Kim, Mayers and Smith. (1991)

<p align="center">Table 4 A Comparison of Variation in Underwriting Experience and Investment Income By Line During 1976 - 80 and 1986 - 88^a</p>																			
		μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
All Lines	76-80	63.6	2.7	9.24	0.21	12.94	0.21	12.95	0.55	1.42	0.28	5.98	0.30	94.18	2.42				
	86-88	67.75	2.14	11.57	0.25	11.87	0.08	33.5	0.35	1.35	0.05	9.2	0.46	95.8	1.99				
	Change	4.15	-0.05	2.33	0.04	-1.07	-0.13	20.5	-0.18	-0.09	-0.2	3.22	-0.45	1.6	-0.43				
	t or F	2.67***	1.65	13.41***	1.94	6.53***	12.5	1.49	2.55	-0.52	20.1	5.07***	4.45	1.52	1.51				
Homeowner Multiple Peril	76-80	58.46	5.37	7	0.37	18.35	0.35	12.85	0.15	0.64	0.13	7	0.25	94.35	5.21				
	86-88	59	2.95	9.5	0.2	16.87	0.51	14.17	0.13	0.53	0.12	4.87	0.12	95.2	3.2				
	Change	0.52	-2.42	2.5	-0.17	-1.65	-0.02	1.31	0	-0.11	-0.01	1.71	-0.17	0.85	-2.01				
	t or F	(1.15)	3.51	10.49***	3.5	-6.70***	1.42	11.77***	1.01	-1.14	1.55	9.95***	6.22	0.25	2.65				
Auto Liability	76-80	45.8	2.75	11.38	0.34	10.42	0.25	15.35	0.25	0.88	0.37	6.32	0.68	95.54	2.51				
	86-88	51.05	1.17	12.7	0.48	9.43	0.05	13.47	0.21	0.95	0.15	9.5	0.17	95.7	1.58				
	Change	5.15	-1.58	1.32	0.1	-0.99	-0.2	0.15	-0.07	-0.05	-0.22	3.18	-0.47	12.22	-0.93				
	t or F	10.67***	3.05	4.81***	1.52	-6.21***	20.10	0.67	1.8	-0.2	5.87	8.16***	15.7	8.98***	4.58				
Other Liability	76-80	55.14	3.05	10.45	1.05	14.14	0.25	12.85	1.35	0.54	0.07	11.32	2.04	93.05	4.25				
	86-88	58.17	5.75	23.85	1.48	10.65	0.64	11.43	1.22	0.25	0.21	15.77	2.4	96.77	3.51				
	Change	11.05	2.48	4.52	0.45	-3.51	1.35	-1.45	-0.11	-0.31	0.12	4.45	0.35	3.11	1.26				
	t or F	3.55**	3.12	5.19***	2.05	-10.30***	4.98	-1.45	1.18	-2.99**	5.42	2.81**	1.38	1.77	1.68				
<p>a. t (F) statistics reflect test against null hypothesis of equal means (standard deviations). *** Significant at .01 level; ** at .05 level; * at .10 level.</p>																			
Source: The data for analysis in this table was obtained from various issues of Best's Aggregates and Averages, A. M. Best Company.																			

CONCLUSIONS AND POLICY IMPLICATIONS

We have developed an economic model that can offer a more comprehensive explanation of the commercial liability crisis. The model incorporates loss shocks, expectation changes, and underpricing.⁴¹ While loss shocks and underpricing are important phenomena, this paper emphasizes the role of expectation changes in generating a crisis. The model includes the changes in expectations on both demand and supply sides of the market. Changes in insurer expectations shifted the supply and resulted in a smaller and more inelastic supply. The changes in consumer expectations amplified the crisis by shifting demand. The model predicts an increase in the equilibrium premium, when the mean and variance of expenses and

⁴¹ Trebilcock (Trebilcock 1987) suggested that adverse trends in the U.S. tort system made it very difficult for insurers to predict and price various risks. Clarke et. al. (1988) have provided some empirical evidence which supports the uncertainty hypothesis. None of the literature, however, formally models the uncertainty hypothesis.

losses increase. The empirical results of cross-sectional regression analysis are consistent with the predictions. The model also predicts an increase in the equilibrium premium when the mean interest rate decreases. Our time-series analysis is also consistent with the prediction. It is interesting to note that the equilibrium is not affected by changes in interest rate risk and our empirical evidence is also consistent with that prediction. In addition, some empirical evidence necessary to reject the greed hypothesis is provided. While loss shocks and under-pricing are important aspects of the crisis explanation, the analysis here shows that the changing expectations on both sides of the market also provide important insights into an understanding of the crisis.

Public policy implications of the analysis would suggest that all the parties involved in the commercial liability insurance market need to find ways to reduce the expected values and variances of losses and expenses through loss prevention and control. The development of a more stable legal system that may require some major tort reform may also be needed in order to reduce legal uncertainty.

Various policies and strategies have been utilized or proposed to solve the liability crisis. Such strategies will be briefly assessed in terms of their impact on the reduction of expected values and variances of losses and expenses. Since the recent crisis seems to have resulted from changes in expectations caused by unanticipated growth in losses and expenses, and decreases in interest rates which increased uncertainty, increased governmental regulation of liability insurance rates would seem to be unwarranted. Moreover, no meaningful and convincing arguments have been developed for the repeal of the McCarran-Ferguson Act for the same reasons.

The Justice Department and the Alliance of American Insurers have recommended tort reform. The suggested reforms include instituting a cap on awards for pain and suffering and other non-economic losses, developing a uniform national product liability law, abolishing joint and several liability, adopting scientific causation standards, and reducing lawyers' contingency fees. It is clear that the proposed reforms are designed to reduce not only the expected value of losses and expenses but also their associated variances. For example, the adoption of a uniform product liability law would be designed to reduce the uncertainty associated with the state legal systems in this area more than the expected losses. Moreover, it is clear that loss adjustment expenses are also an important and growing factor contributing to problems in the liability insurance market. This explains why reducing or grading lawyers' contingency fees has been recommended because it would reduce the incentives they provide for creative and talented trial attorneys to file lawsuits. Requiring the losing side in a legal action to pay the legal fees of the winning side has also been proposed but has not received much support.

In responding to the crisis, insurers modified liability insurance policy forms in order to reduce both expected values and risks. The strategies included reduction of coverage limits, increased deductibles, charging legal expenses against the policy limit in primary and excess layers, and the adoption of claims-made policies in various liability insurance areas. Again, all of the above modifications were designed to reduce both the expected values and uncertainties. Note that charging legal expenses against limits and increased deductibles will tend to reduce future expenses where such changes are instituted. Insurer attempts to reduce expenses through such approaches provide

evidence that expenses were important to the crisis which helps to support our hypothesis that expenses were also a causal factor for the liability insurance crisis, especially legal costs.

In summary, all of the proposed tort reforms or modified policies would help to reduce the expected values and uncertainty associated with commercial liability insurance contracts. Moreover, the reduction of uncertainty with respect to legal standards would be very desirable because the reduction of such uncertainty would enable insurers to predict losses and expenses more accurately and result in reduced risk charges and premiums. Furthermore, some liability insurance such as pollution liability insurance might become available if terms such as "sudden and accidental" were interpreted in a reasonable manner without judicially mandated redistribution of wealth on an ex-post basis.

Other Liability				
Year	Premiums	Loss	Expenses	Investment
1981	\$ 6,046.00	\$ 1,700.15	\$ 3,296.16	\$ 1,172.92
1982	\$ 5,668.00	\$ 3,839.26	\$ 3,379.34	\$ 1,309.31
1983	\$ 5,679.00	\$ 4,253.57	\$ 3,587.61	\$ 1,385.68
1984	\$ 6,479.00	\$ 5,656.17	\$ 3,987.50	\$ 1,723.41
Mean	\$ 5,968.00	\$ 4,187.29	\$ 3,562.65	\$ 1,397.63
StdDev	383	876	309	234
1984	\$ 6,479.00	\$ 5,656.17	\$ 3,987.50	\$ 1,723.41
1985	\$ 11,544.00	\$ 10,562.76	\$ 5,012.55	\$ 2,308.80
1986	\$ 19,365.00	\$ 13,923.44	\$ 7,397.36	\$ 2,711.10
1987	\$ 20,874.00	\$ 13,617.97	\$ 8,933.38	\$ 3,082.35
Mean	\$ 14,565.50	\$ 10,990.07	\$ 6,332.69	\$ 2,458.17
StdDev	6766	3883	2246	523
	5000			
Units	1209200			
Unit Means	4935	3628	2946	1156
Proportional	2.44	2.50	1.78	1.76
Unit StdDev	317	724	255	194
Proportional	17.65	4.43	7.28	2.50

APPENDIX

Loss Shock Theorem. A fixed interest rate and decreasing absolute risk aversion suffice to show that the supply function is increasing in the surplus.

Proof. Let the function H be defined as

$$H(n, S) = \int_{\Lambda} u'(\Pi(n)) [i(1+r) - 1] dF$$

where $\Pi(n) = (i n + S)(1+r) - \lambda n$. Note that $H(n, S) = 0$ at the optimal number of policies. It follows simply that the number of policies supplied by the firm is increasing in the surplus if

$$\frac{dn}{dS} = - \frac{\frac{\partial H}{\partial S}}{\frac{\partial H}{\partial n}} > 0 \quad (25)$$

The denominator is negative due to risk aversion. The numerator is positive if the company exhibits decreasing absolute risk aversion.

To sign the numerator in (25) observe that

$$\frac{\partial H}{\partial S} = \int_{\Lambda} u''(\Pi) (i(1+r) - 1) (1+r) dF$$

Let $\lambda^* = i(1+r)$ so that $\Pi^* = S(1+r)$. Note that $\lambda < \lambda^*$ yields $\Pi > \Pi^*$ and $i(1+r) - \lambda > 0$. Letting $a = -u''/u'$ denote the measure of

absolute risk aversion, observe that for $\lambda < \lambda^*$ we obtain $a(\Pi^*) > a(\Pi)$ and the following sequence of equivalent statements:

$$-\frac{u''(\Pi^*)}{u'(\Pi^*)} > -\frac{u''(\Pi)}{u'(\Pi)}$$

$$u''(\Pi) > -a(\Pi^*) u'(\Pi)$$

$$u''(\Pi) (i(1+r) - 1) > -a(\Pi^*) u'(\Pi) (i(1+r) - 1)$$

Similarly, $\lambda > \lambda^*$ yields $\Pi < \Pi^*$ and $i(1+r) - \lambda < 0$. Then we obtain $a(\Pi^*) < a(\Pi)$ and the following sequence of equivalent statements:

$$u''(\Pi) < -a(\Pi^*) u'(\Pi)$$

$$u''(\Pi) (i(1+r) - 1) > -a(\Pi^*) u'(\Pi) (i(1+r) - 1)$$

It follows that

$$\begin{aligned} \frac{\partial H}{\partial S} &= E\{u''(\Pi) (i(1+r) - 1)\} \\ &> -a(\Pi^*) E\{u'(\Pi) (i(1+r) - 1)\} \\ &= 0 \end{aligned} \tag{26}$$

Hence, decreasing absolute risk aversion suffices to show that supply is increasing in the surplus.

REFERENCES

- Berger, L. A. and J. D. Cummins (1992). "Adverse Selection and Equilibrium in Liability Insurance Markets." *Journal of Risk and Uncertainty* 5(3): 273-88.
- Brockett, Patrick L., William W. Cooper, Linda L. Golden, John Rousseau, and Yuying Wang (1998) "DEA Evaluation of the Efficiency of Organizational Forms and Distribution Systems in the U.S. Property and Liability Insurance Industry," *International Journal of Systems Science* (1998), Vol. 29, No. 11, 1235-1247.
- Brockett, Patrick L., William W. Cooper, Linda L. Golden, John Rousseau, and Yuying Wang (1999) "Solvency and Efficiency in the Insurance Industry," Working paper, University of Texas at Austin Center for Risk Management and Insurance
- Brockett, Patrick L. and Robert C. Witt (1982) "The Risk and Return Paradox Revisited", *Journal of Risk and Insurance* (54)1: 9-20
- Clarke, R. N. and et al. (1988). "Sources of the Crisis in Liability Insurance: An Economic Analysis." *Yale Journal on Regulation* 5(2): 367-95.
- Cummins J. David (1987). "1986 Presidential Address-Revitalizing Risk and Insurance Education and Research." *Journal of Risk and Insurance* (54)1: 9-20.
- Cummins, J. D. and P. M. Danzon (1997). "Price, Financial Quality, and Capital Flows in Insurance Markets." *Journal of Financial Intermediation* 6: 3-38.
- Cummins, J. D., S. E. Harrington, et al., Eds. (1991). *Cycles and Crises in Property/Casualty Insurance: Causes and Implications for Public Policy*. Kansas City, Missouri, National Association of Insurance Commissioners.

- Cummins, J. D. and J. B. McDonald (1992). *Risky Probability Distributions and Liability Insurance Pricing. Cycles and Crises in Property/Casualty Insurance: Causes and Implications for Public Policy*. J. D. Cummins, S. E. Harrington and R. W. Klein. Kansas City, Missouri, National Association of Insurance Commissioners.
- Cummins, J. D. and J. F. Outreville (1987). "An International Analysis of Underwriting Cycles in Property-Liability Insurance." Journal of Risk and Insurance 54(2): 246-62.
- Doherty, N. A. and J. R. Garven (1995). "Insurance Cycles: Interest Rates and The Capacity Constraint Model." Journal of Business 68(3): 383-404.
- Doherty, N. A. and H. B. Kang (1988). "Interest Rates and Insurance Price Cycles." Journal of Banking and Finance 12: 189-214.
- Harrington, S. and R. Litan (1988). "Causes of the Liability Insurance Crisis." Science 239: 737-741.
- Harrington, S. E. (1988). Prices and Profits in the Liability Insurance Market. Liability: Perspectives and Policy. R. E. Litan and C. Winston. Washington, D.C., Brookings Institution: 42-100.
- Harrington, S. E. and P. M. Danzon (1994). "Price Cutting in Liability Insurance Markets." Journal of Business 67(4): 511-38.
- Justice, U. S. D. o. (1986). Report on the Tort Policy Working Group on the Causes, Extent, and Policy Implications of the Current Crisis in Insurance Availability and Affordability, U.S. Department of Justice.
- Kimball, S. L. (1988). "Should McCarran-Ferguson Be Repealed or Amended." Journal of Insurance Regulation 7(2): 165-179.
- Lacey, N.-J. (1988). "Recent Evidence on the Liability Crisis." Journal of Risk and Insurance 55(3): 499-508.

- Lai, G. C. and R. C. Witt (1992). "Changed Insurer Expectations: An Insurance-Economics View of the Commercial Liability Insurance Crisis." Journal of Insurance Regulation.
- NICO (1986). *The Liability Insurance Crisis*. Washington, D.C., National Insurance Consumer Organization.
- Priest, G. L. (1987). "The Current Insurance Crisis and Modern Tort Law." Yale Law Journal 96(7): 1521-1590.
- Sandmo, A. (1971). "On the Theory of the Competitive Firm Under Price Uncertainty." American Economic Review 61: 65-73.
- Trebilcock, M. J. (1987). "The Social Insurance Deterrence of Modern North American Tort Law: A Canadian Perspective on the Liability Insurance Crisis." San Diego Law Review 24: 929.
- Winter, R. A. (1988). "The Liability Crisis and the Dynamics of Competitive Insurance Markets." Yale Journal on Regulation 5(2): 455-99.
- Winter, R. A. (1991). "The Liability Insurance Market." Journal of Economic Perspectives 5(3): 115-36.
- Witt, R. C. (1973). "Pricing and Underwriting Risk in Automobile Insurance: A Probabilistic View." Journal of Risk and Insurance 40(4): 509-530.
- Witt, R. C. (1973). "Pricing Problems in Automobile Insurance: An Economic Analysis." Journal of Risk and Insurance 40(1): 75-93.
- Witt, R. C. and P. Aird (1992). "Contestable Markets for Property-Liability Insurance: Is Rate and Form Regulations Necessary?" CPCU Journal 45(1): 30-48.
- Witt, R. C. and J. Urrutia (1983). "Price Competition, Regulation, and Systematic Underwriting Risk in Automobile Insurance." Geneva Papers on Risk and Insurance 8(29): 403-429.