On Liability Insurance Crises

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I. Introduction

The liability insurance crisis from late 1984 through 1986 was characterized by major economic disruptions in the commercial liability insurance market that created public policy concerns about the availability and affordability of certain coverages. Many professional and commercial liability insurance consumers were adversely affected by the crisis, including chemical and pharmaceutical companies, day-care centers, medical doctors, and municipalities. The crisis in the commercial liability insurance market was characterized by a sudden increase in liability premiums in late 1984 after about six years of relatively stable prices; the policy limits and scope of coverage were reduced in commercial liability lines with long-tails; some insurers were unwilling to provide any coverage for some risks, especially those involving pollution liability exposures.[1]

The causes of the commercial liability insurance crisis have never been agreed upon by academics, attorneys general, consumers, insurers, or regulators. The crisis theories in the literature share two characteristics. First, the theories focus on the supply of liability insurance and ignore the demand. The demand for commercial liability insurance during the crisis period, while implicit in some theories, is generally not addressed. Second, the theories emphasize one factor as the cause of the crisis.

The shared characteristics of the crisis explanations create problems. The single factor theories do not explain enough aspects of the crisis, even though each offers some insight. The U. S. Justice Department (Justice 1986) has sited the expansion of business liability under tort law as the factor explaining higher premiums and reduced coverage

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[1]Another 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

limits. The expansion of business liability under tort law, however, has been occuring over an extended period; that 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 cause of either the sudden elimination of some liability coverages or the sudden increase in commercial premiums.[2] In fact, single factor hypotheses do not seem to explain why net written premiums for general liability insurance increased from about $6.5 billion in 1984 to approximately $19.5 billion in 1986.[3]

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 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." [4] 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.

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

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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)

[2] See Table two in (Winter 1988), p.873.

[3] This reported increase is based on data from the A.M. Best Company.

[4] See (Priest 1987), p. 1531.

liability insurance has been developed. Second, on the supply side, most of the empirical studies are performed to test one specific hypothesis rather than a combination of several hypothesis. 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."[5]

None of the existing hypotheses alone can explain enough aspects of the commercial liability insurance crisis, especially the large scale increases in premiums during the crisis period. Due to the unsettled nature of the literature, concerned parties are left to wonder what the actual causes of 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.

The purpose of this paper is to develop an economic model that can offer a more comprehensive explanation of the commercial liability insurance crisis. The model integrates some of the competing hypotheses to provide a coherent theory of the causes of the commercial liability insurance crisis. The model developed here also suggests some empirical tests. The model 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 reduce the impact of future liability crises on all concerned parties that are discussed.

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[5] See (Winter 1991), p. 133.

On the Commercial Liability Insurance Crisis

The premise here is that the crisis occurred due to changes in expectations on both sides of the market. The changes in insurer expectations reduced the supply of liability coverage. The increase in the expected values and variances of future losses and expenses, in part due to a changing and expanding tort liability system, and a decrease in interest rates were all contributing causes of the crisis. These changes help explain a smaller more inelastic supply that, *ceteris paribus*, caused firms to assume more of their liability exposures. The changes in consumer expectations increased demand. Those changed expectations help 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 price increases and so the reduced coverage. Hence, the changes in insurer expectations shifted the supply and the changes in consumer expectations amplified, rather than dampened, the crisis by shifting demand.

This study complements the literature on the commercial liability insurance crisis in several ways. First, in contrast to the existing literature, this theory incorporates multiple factors to explain the liability insurance crisis. Second, this theory completes existing theories by modelling the insurance demand. Third, the paper provides new empirical evidence on the crisis using cross-sectional data. The results strongly 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. More than 59% of the variation in premiums could be explained by the model if the interest rate factor had been considered. 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.

II. Related Literature

What theories exist that explain the crisis? 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. The second includes the loss shock theories; Cummins and Danzon 1991, Gron 1990 and Winter 1986, 1988, and 1991 consider the role that loss shocks play in generating a crisis. The third category includes the interest rate theories, e.g., Doherty and Garven 1995. The fourth consists of the underpricing 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.[6] This theory, however, has not received much support in the literature.[7] The other theories form the basis for what appears to be a consensus.

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[6]Federal anti-trust law applies to insurers only to the extent that insurance is not regulated by state law. However, conduct or acts involving boycott, coersion, or intimidation are not exempt from federal law.

[7]This 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

There is a growing consensus on why the crisis occurred. Cummins, Harrington, and Klein 1991 (Cummins, Harrington et al. 1991) point to **loss shocks**, **interest rate changes**, and **underpricing** 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 expectation changes would include interest rates, the revised list would not be limited to interest rate changes. The changes would also include expectations regarding underwriting losses and expenses. The combined impact of all the changing expectations can have a dramatic effect on the structure of demand and supply in the 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 contracts. A loss shock may have an impact on loss expectations but the two concepts are different. The loss shock refers to the past while the loss expectation refers to the future.

The discounted cash flow construct common to most theories generates an insurance supply function that is perfectly elastic; the premium is the present value of the expected unit loss. Hence, the discounted cash flow approach makes it difficult to explain a 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 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 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.

The National Insurance Consumer Organization (NICO 1986) suggested a mismanagement and greed theory but the argument fits this loss shock category.[8] According to this argument the dramatic increase in commercial liability premiums were needed to compensate insurers for unexpected increases in past losses from the early 1980s.[9] 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.

Interest Rate Changes

Interest rate changes affect all financial values and so must form part of any explanation. In this thread of the literature, the duration measure is used. Recall that if the durations of a firm's assets and liabilities are not appropriately matched then interest rate changes can cause disproportionate changes in value. Doherty and Garven (Doherty and Garven 1995) use the duration concept and observe that insurance firms have not selected capital structures that yield immunization from interest rate changes. Then interest rate changes cause changes in capital structure; the corporation must

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[8]National Insurance Consumer Organization, The Liability Insurance Crisis, 1986. While it may be possible that there may have been some imprudent management of a few insurance companies leading up to and during the liability crisis, this paper will primarily focus on stronger economic explanations for the crisis in the various liability lines. 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.

[9]In competitive and contestable marketa, such premium increases would not be viable or feasible, (Witt and Aird 1992).

respond by increasing its equity value and because an outside equity issue is not feasible the firm must raise equity internally, i.e., by increasing premiums.

Under-Pricing

Insurance markets are sometimes characterized as soft or hard markets. In a soft market there is some under-pricing that contributes to a subsequent crisis. Harrington and Danzon (Harrington and Danzon 1994) propose this approach using differential expectations and excessive risk taking arguments.

Comments

Most theories in the literature at least **implicitly** assume that diversification is possible.   This often leads to a risk neutrality assumption, e.g. in a discounted cash flow setting the firm may be assumed to be risk neutral so that it supplies contracts at a premium equal to the discounted value of the expected losses; the risk neutrality assumption, however, is flawed. 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 choose 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; then a risk averse agent 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 accident 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 the maximization of current shareholder value; if the accident risks cannot be well diversified then management will behave in a risk averse manner.

Finally, the financial constraint thread of the literature in both the loss shock and interest rate changes theories represents an innovative approach but, from a purist's viewpoint, is very limited because the financial constraint is *ad hoc* and therefore supply is also. The constraint is motivated by fragments of theory that exist but the constraint is not endogenous; this leaves us with a proof by assumption method of explaining the crisis which is not satisfactory. It should also be noted that in the financial constraint theory, expectations do not have to change because a large loss or interest rate change suffices to change the capital structure and trigger the crisis. This suggests that it would be possible to test the theory by seeing if most large loss events for the industry are associated with a crisis. A more general theory that generates the behavior assumed by the constraint is needed. The basis for such a theory is introduced in the next section. It contains elements of the loss shock and interest rate change theories and could be generalized to introduce the under-pricing theory. It also extends the expectations in the interest rate theory to include other expectation parameters.

III. The Liability Insurance Market

In this section, we hope to provide the seeds of a synthesis. 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 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 underpricing, i.e., soft (hard) markets can be explained using the relative size of the surplus. The interest rate and other expectation changes also impact the supply and demand. In part of the analysis, the standard constant absolute risk aversion and normal distribution assumptions are made to allow an explicit derivation of the supply and demand functions. These behavioral functions are animated using historical data and provide a sufficient motivation for a crisis.

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.[10] Finally, assume that the market is perfectly competitive so that no agent has an ability to control the insurance premium. While these are strong assumptions, they do allow a portrayal of equilibria in the insurance market that are consistent with the existence 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 on both sides of the market. This is a departure from much of the insurance crisis literature where the risk

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[10] This iid assumption would have to be changed to allow for the adverse selection theory.

neutrality assumption has played such a prominant role;[11]   the risk neutrality assumption, however, is flawed[12] and does not provide the power necessary to explain the 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 is a behavioral function that provides the number of contracts that the insurance firm is willing to sell at each possible premium. The following notation is used in the development of the insurance supply function.

i	insurance premium per policy
n	number of policies
ℓ	random loss on a standard exposure unit
e	random expense per policy[13]
S	company surplus
r	random interest rate
Π	insurance company income, i.e.,

$$\Pi = (i\, n + S)\,(1 + r) - (\ell + e)\, n$$

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[11] 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.

[12] 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 maximized 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.

[13] The unit expense e is assumed to be random in order to capture the uncertainty about future expenses, especially legal defense costs. Legal expenses for loss adjustment or claim settlement have tended to become unpredictable during recent years because of the expanding and uncertain nature of litigation. For a detailed discussion of cost problems in the legal defense area, see (1989; 1991).

The surplus is the amount carried forward by the company to ensure the payment of losses; it is a stock variable that is affected by loss shocks.

Suppose insurance company selects the number of policies to sell to maximize the expected utility of the company income. Letting u denote the utility function, F denote the joint distribution function, and Λ denote the support of the distribution function, the insurance company selects the number of policies to solve the following problem:

$$\max imize \int_{\Lambda} u(\Pi(n)) \ dF(e, \ell, r)$$

The first order condition, i.e.,

$$\int_{\Lambda} u'(\Pi(n)) \ \frac{\partial \Pi}{\partial n} \ dF(e, \ell, r) = \int_{\Lambda} u'(\Pi(n)) \left[i\left(1+r\right) - \ell - e \right] dF = 0$$

implicitly defines the supply function of the firm. The first order condition also implies a relationship between the surplus and the supply. Let the function H be defined as

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

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

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

The denominator is negative due to risk aversion. The numerator is positive if the company exhibits decreasing absolute risk aversion.[14] Therefore, decreasing absolute risk aversion suffices to show that the supply is increasing in the surplus. It is possible to interpret a loss shock in this setting as a reduction in surplus; then this result shows that supply decreases with a loss shock. Hence, this model does generate a loss shock interpretation for 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.

Next, consider a special case of the model that allows an explicit derivation of the supply and subsequently the demand. 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 having 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. If management makes decisions to maximize expected utility then the objective function can also be expressed as

$$\mu_\Pi - \frac{1}{2}\,a\sigma_\Pi^2.^{15}$$

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[14] 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.

[15] In general if $u(\pi) = -\exp(-a\,\pi)$ then $Eu(\Pi) = -M(-a)$, where M is the moment generating functin of Π. Note that $M(t) = E(\exp(t\,\Pi))$ and so $E(-\exp(-a\,\Pi)) = -M(-a)$. For $\Pi \sim N(\mu_\Pi, \sigma_\Pi^2)$,

$$M(t) = \exp\left(\mu_\Pi\,t + \frac{1}{2}\,\sigma_\Pi^2\,t^2\right)$$

Therefore

$$E\left(-\exp\left(-a\,\Pi\right)\right) = -\exp\left(-a\left(\mu_\Pi - \frac{1}{2}\,a\,\sigma_\Pi^2\right)\right)$$

The second term is the risk premium. It is possible to restate the objective function in equivalent form as

$$\mu_\Pi - \frac{1}{2} a \, \sigma_\Pi^2 = \left(1 + \mu_r\right)\left(i\, n + S\right) - \left(\mu_\ell + \mu_e\right) n - \frac{1}{2} a \left(\sigma_\ell^2 + \sigma_e^2 + i^2 \sigma_r^2\right) n^2 \tag{1}$$

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

$$\left(1 + \mu_r\right) i - \mu_\ell - \mu_e - a \left(\sigma_\ell^2 + \sigma_e^2 + i^2 \sigma_r^2\right) n = 0 \tag{2}$$

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

$$n = s(i; \mu, \sigma) = \frac{\left(1 + \mu_r\right) i - \mu_\ell - \mu_e}{a\left(\sigma_\ell^2 + \sigma_e^2 + i^2 \sigma_r^2\right)} \tag{3}$$

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

$$i^0 = \frac{\mu_\ell + \mu_e}{\left(1 + \mu_r\right)}$$

This simply says that the insurance company is only willing to sell contracts at premiums that exceed the present value of the expected losses and expenses. 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. For some parameter choices the supply may be backward bending as shown in figure one. This backward bend in supply is not crucial

to 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, i.e., the parameters μ_ℓ and σ_ℓ^2.

Figure 1: Supply[16]
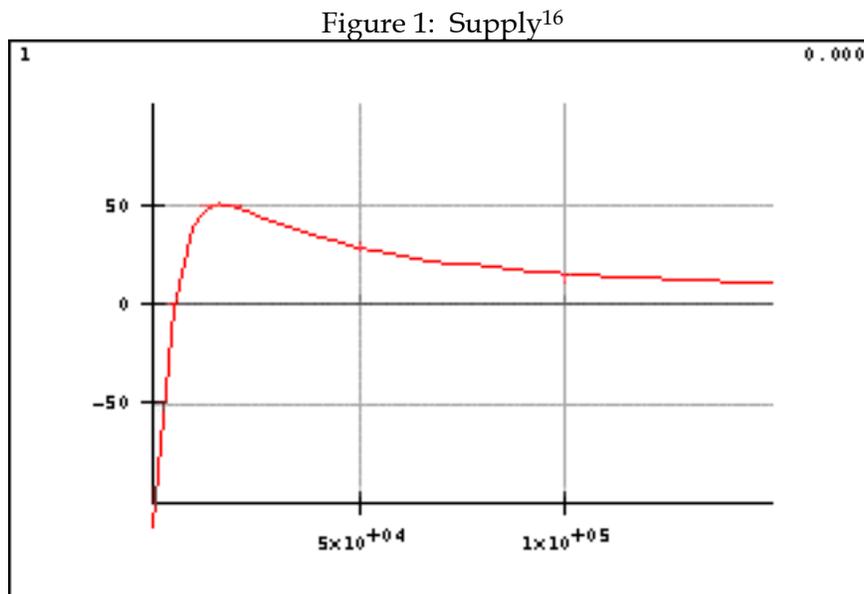
This animation shows that the insurance company limits the number of policies written and increases the premiums for those it does write. It also shows that the supply becomes inelastic as the underwriting expense risk becomes indefinitely large; equivalently,

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[16]This animation is a quicktime movie that can also be accessed directly on the web at <http://kiwiclub.bus.utexas.edu/crisis/supply.mov>.

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

since

$$\frac{\partial s}{\partial i} = \frac{\left(1 + \mu_r\right)}{a\left(\sigma_\ell^2 + \sigma_e^2 + i^2 \sigma_r^2\right)} - \frac{2 \, a \, i \, \sigma_r^2 \left(\left(1 + \mu_r\right) i - \left(\mu_\ell + \mu_e\right)\right)}{\left(a\left(\sigma_\ell^2 + \sigma_e^2 + i^2 \sigma_r^2\right)\right)^2}$$

An increase in loss risk has the same impact since the derivative properties are the same, i.e.,

$$\frac{\partial s}{\partial \sigma_\ell^2} = \frac{\partial s}{\partial \sigma_e^2} = -\frac{n}{i^2 \sigma_r^2 + \sigma_e^2 + \sigma_\ell^2} < 0 \tag{4}$$

An increase in interest rate risk also limits the number of contracts the company is willing to supply since

$$\frac{\partial s}{\partial \sigma_r^2} = -\frac{i^2 \, n}{i^2 \sigma_r^2 + \sigma_e^2 + \sigma_\ell^2} < 0 \tag{5}$$

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

$$\frac{\partial s}{\partial \mu_\ell} = \frac{\partial s}{\partial \mu_e} = -\frac{1}{i^2 \sigma_r^2 + \sigma_e^2 + \sigma_\ell^2} < 0 \tag{6}$$

$$\frac{\partial s}{\partial \mu_r} = \frac{i}{i^2 \sigma_r^2 + \sigma_e^2 + \sigma_\ell^2} > 0 \tag{7}$$

The Demand for Insurance Contracts

The demand is a behavioral function that provides the number of contracts that the commercial 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

      Γ commercial firm income, i.e.,

      $\Gamma \equiv Pq - c(q) - (1 + r)\,i\,n - (N - n)\,(\ell + e)$

Suppose commercial companies select the number of policies n to buy to maximize the expected utility of the company income. Suppose that Γ is normally distributed with mean

$$\mu_\Gamma = \mu_p q - c(q) - \left(1 + \mu_r\right) i\ n - \left(N - n\right)\left(\mu_\ell + \mu_e\right)$$

and variance

$$\sigma_\Gamma^2 = \sigma_p^2\, q^2 + \left(i\ n\right)^2 \sigma_r^2 + \left(N - n\right)^2 \left(\sigma_\ell^2 + \sigma_e^2\right)$$

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

$$\text{maximize } \mu_\Gamma - \frac{1}{2} a \sigma_\Gamma^2$$

$$(8)$$

$$\text{subject to } n \leq N$$

If the constraint is not binding then the first order condition for insurance is

$$-\left(1 + \mu_r\right) i + \left(\mu_\ell + \mu_e\right) - a\left(i^2 n \sigma_r^2 - (N - n)\left(\sigma_\ell^2 + \sigma_e^2\right)\right) = 0 \qquad (9)$$

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

$$n = d(i; \mu, \sigma) = \max\left\{N, \frac{N a \left(\sigma_\ell^2 + \sigma_e^2\right) - \left[\left(1 + \mu_r\right)i - \mu_\ell - \mu_e\right]}{a\left(i^2 \sigma_r^2 + \sigma_\ell^2 + \sigma_e^2\right)}\right\} \qquad (10)$$

Note that if the interest rate is safe and the premium is equal to the present value of the expected unit losses and expenses then the company covers all the insurable losses. Figure two shows the shape of the demand function, without the constraint, for a particular choice of mean and standard deviation parameters.
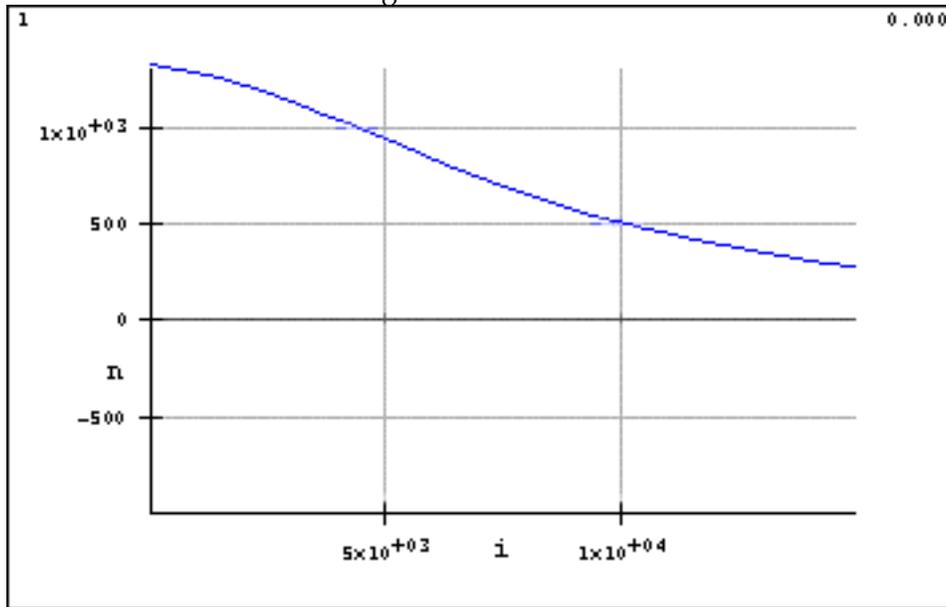
Figure 2: Demand[17]

Figure two also contains an animation, i.e., 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,

$$\left| \frac{\partial d}{\partial i} \right| \to 0 \text{ as } \sigma_\ell^2 \to \infty$$

since

$$\frac{\partial d}{\partial i} = \frac{a\left(i^2\sigma_r^2 + \sigma_\ell^2 + \sigma_e^2\right)\left(-\left(1+\mu_r\right)\right)}{\left(a\left(i^2\sigma_r^2 + \sigma_\ell^2 + \sigma_e^2\right)\right)^2}$$

$$-\frac{\left(N\,a\left(\sigma_\ell^2 + \sigma_e^2\right) - \left[\left(1+\mu_r\right)i - \left(\mu_\ell + \mu_e\right)\right]\right)2\,a\,i\,\sigma_r^2}{\left(a\left(i^2\sigma_r^2 + \sigma_\ell^2 + \sigma_e^2\right)\right)^2}$$

$$= -\frac{\left(1+\mu_r\right)}{a\left(i^2\sigma_r^2 + \sigma_\ell^2 + \sigma_e^2\right)} - n\,\frac{2\,a\,i\,\sigma_r^2}{a\left(i^2\sigma_r^2 + \sigma_\ell^2 + \sigma_e^2\right)}$$

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.,

$$\frac{\partial d}{\partial \mu_\ell} = \frac{1}{a\left(i^2\sigma_r^2 + \sigma_\ell^2 + \sigma_e^2\right)} > 0 ; \quad \frac{\partial d}{\partial \sigma_\ell^2} = \frac{N-n}{i^2\sigma_r^2 + \sigma_\ell^2 + \sigma_e^2} \geq 0 \tag{11}$$

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.,

$$\frac{\partial d}{\partial \mu_r} = -\frac{i}{a\left(i^2\sigma_r^2 + \sigma_\ell^2 + \sigma_e^2\right)} < 0 ; \quad \frac{\partial d}{\partial \sigma_r^2} = -\frac{i^2 n}{i^2\sigma_r^2 + \sigma_\ell^2 + \sigma_e^2} < 0 \tag{12}$$

Remarks

One of the advantages of this simple model is that it is capable of recognizing and combining the changes in economic factors on insurer expectations into one aggregate effect. This advantage makes the stylized model presented here general

enough to, directly or indirectly, incorporate some of the existing hypotheses into one model and integrate their predictions to form a reasonable economic explanation of the liability insurance crisis on price and output decisions of commercial liability insurers. For example, **tort law theory** suggests that increased losses and loss adjustment expenses were the main factors that caused the liability crisis. Because expected losses and loss adjustment expenses are part of this simple economic model, it can incorporate the tort law theory as part of the explanation of the crisis.

This model is not designed to include **adverse selection theory**. The adverse selection theory suggests that the extraordinary increases in premiums were due to the departure of low-risk insureds from the commercial liability insurance market leaving high-risk exposures in the commercial market pool. The implication of the adverse selection theory is that the expected losses substantially increased before and during the crisis period. While the model presented here does not include adverse selection, it does demonstrate the increase in premiums due, in part, to an increase in expected losses; it also allows for a richer set of parameters than the adverse selection theory.

This model can capture the essence of **risk theory** because the variance terms in the model serve as proxies for the risks associated with losses, expenses, and interest rates. The **underwriting theory** is also part of a model that explicitly considers investment income. The model here is consistent with the cashflow underwriting theory because the parameters (μ, σ) include those in the cashflow underwriting theory, are prospective, and because the time value of money is explicitly recognized.

IV. Market Equilibria

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. The hypothesis is that the liability crisis was caused by changes in

the expectations, i.e., (μ, σ), of insurers that adversely affected supply and that the corresponding changes in the expectations of the commercial buyers shifted demand in a manner that amplified rather than dampened the premium changes.

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

Since expenses, 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 expenses, losses, and investment income. Past experience alone, however, can yield lags in adjusting expectations.[18] 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; a change in legal precedent will not be reflected in such a history but can have an impact on the expense and loss distributions. Such a change causes a revision in the anticipated distributions by forwarding looking market agents. Therefore, both past and anticipated experience have to be evaluated by firms in forming expectations about the future.[19]

Firms will change their behavior if one or more of the factors influencing their expectations change. Given the risk averse agent assumption used here, not only the means but also the variances of expenses, losses, and interest rates are the important

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

[19]Most state rate regulatory statutes recognize this fact; see (Witt 1973; Witt 1973; Witt and Urrutia 1983).

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 past experience and future 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.

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

$$s(i,\mu,\sigma) = \sum_{f=1}^{N_s} s_f(i,\mu,\sigma) \tag{13}$$

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

$$d(i,\mu,\sigma) = \sum_{f=1}^{N_b} d_f(i,\mu,\sigma) \tag{14}$$

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

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 relation[20]

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[20] 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.

$$\frac{\left(1+\mu_r\right)i - \left(\mu_\ell + \mu_e\right)}{a\left(i^2\sigma_r^2 + \sigma_\ell^2 + \sigma_e^2\right)} N_s = \frac{N\,a\left(\sigma_\ell^2 + \sigma_e^2\right) - \left[\left(1+\mu_r\right)i - \left(\mu_\ell + \mu_e\right)\right]}{a\left(i^2\sigma_r^2 + \sigma_\ell^2 + \sigma_e^2\right)} N_b$$

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

$$i = f(\mu, \sigma) \equiv \frac{\mu_\ell + \mu_e}{1 + \mu_r} + \frac{a\,N\left(\sigma_\ell^2 + \sigma_e^2\right)}{1 + \mu_r}\frac{N_b}{N_b + N_s} \tag{15}$$

Hence, the equilibrium insurance premium is the present value of the expected loss and expense plus a risk premium. It is interesting to note that the equilbrium premium is not affected by changes in interest rate risk; it does affect supply and demand but that affect is symmetric.[21] The risk premium depends positively on risk aversion, expense risk, loss risk, and the number of agents on each side of the market.

One would expect and equation (15) predicts an increase in premiums, when the mean and variance of expenses and losses increase and the mean interest rate decreases. The hypothesis here is that the crisis was caused by changing expectations that adversely affected the structure of demand and supply.

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

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[21] 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 buyers exist the market and that increases the expected loss 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.

captured here. In constructing the animation, the unit expectations for the pre-crisis years in the data were used and then the parameters were changed by the multiple indicated by the data.[22] 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 one and two. The figure and animation assume the same expectations 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 change 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 (4) through (7) while demand is increasing in the expense and loss expectations as shown in (11) and decreasing in the investment expectations as shown in (12). The combined effects of the expectation changes move the premium higher and cause the number of contracts traded to converge to zero and remain there. The animation, based on the data, is consistent with market failure.

Figure 3: Equilibria[23]

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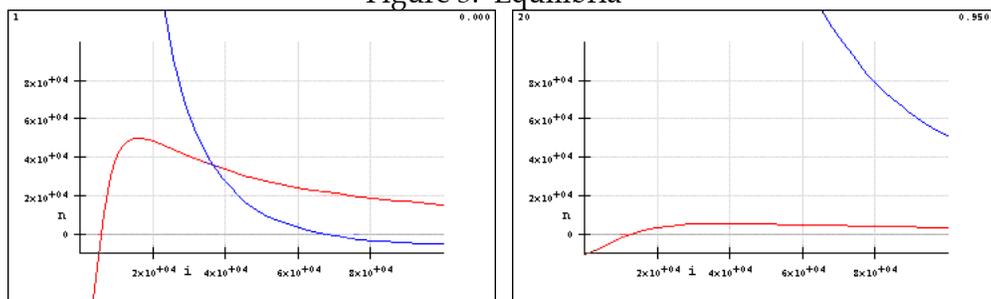
[22] The market data and derived multiples are in the appendix.

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

The animation provides a synthesis and generalization of several of the theories, e.g., tort, risk, and underwriting, and is consistent with the existence of 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.

V. Empirical Evidence

In this section, we present empirical evidence that supports the implications of the theoretical model. In particular, several empirical hypotheses are examined here. First, the economic model suggests that equilibrium premium which is an endogenous variable should be a *positive* function of the expected values and variances of losses and expenses. 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 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.

A. 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 and expenses 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, we postulate that 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 which can be derived from theoretical model is used as follows:

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

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[24]
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

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[24] 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.

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 variance of losses in model 1 was not significant, which 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	-1.433	0.424
	(-0.87)	(-1.54)	(10.23) ***
MLOS	0.327		
	(3.13) ***		
VLOS	0.084	0.183	0.143
	-1.46	(3.55) ***	(3.07) ***
MEXP	0.683	0.76	
	(4.89) ***	(4.70) ***	
VEXP	0.064	0.064	
	(4.68) ***	(4.34) ***	
MPS	-0.613	-0.524	
	(-3.38) ***	(-2.72) ***	
MSIZE	0.062	0.093	
	(1.71) *	(2.51) **	
MRE	0.002	0.002	
	-0.21	-0.18	
MLIQ	-0.356	-0.246	
	(-0.91)	(-0.59)	
ORG	-0.006	-0.044	
	(-0.09)	(-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, variance of losses (VLOS) was 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. 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, 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.[25] Therefore, a separate time series analysis using industry data is performed to provide some evidence on the impact of interest rates in the next subsection.

B. Empirical Evidence Using Industry Data

This subsection provides some statistics on the growth rates of relevant variables that are directly related to the 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.

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[25] It should be noted that interest rates is one of the factors that determines the premium in our theoretical model.

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.

In Table 2, the three-year time period of 1984-1986 is chosen because this period basically represents 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 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).[26]

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 market more than offset losses of business to alternative insurance markets.[27]

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 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

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[26]According 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.

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

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.[28] 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. 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.

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[28]Changing 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 polices 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).

Line	Year	Net Premiums Written		Net Premiums Earned		Losses Incurred		Loss Adjustment Expenses		Commissions and Brokerage Expenses		Other Underwritten Expenses		Net Investmt Gain (Loss) Other Income b	
		μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
Other Liability	79-83	-2.58	3.58	-1.39	5.5	5.98	4.41	9.15	3.65	-4.79	5.86	6.79	4.25	20.12	10.12
	84-86	53.33	34.39	45.38	34.62	41.08	14.58	32.04	12.35	41.85	28.25	22.62	13.89	-15.27	21.19
Change		55.91	30.81	46.77	29.12	35.1	10.17	22.89	8.7	46.64	22.39	15.83	9.64	-35.39	11.07
t or F		3.82**	92.27***	3.13**	39.59***	5.25**	10.94**	4.05***	11.43**	3.76***	23.26**	2.48**	10.69**	-2.71*	4.39

Table 2
Growth Rates and Time Series Variation in Underwriting Experience
During 1979 - 83 and 1984 - 86 [a]

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.

Line	Year	Net Premiums Written		Net Premiums Earned		Losses Incurred		Loss Adjustment Expenses		Commissions and Brokerage Expenses		Other Underwritten Expenses		Net Investmt Gain (Loss) Other Income b	
		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	10.79	9.88	5.6	19.4	11.43
	83-87	33.6	36.45	31.48	31.87	28.53	20.07	23.8	14.26	28.68	27.74	17.48	13.19	-6.89	18.87
Change		34.01	29.28	29.87	22.54	22.45	15.59	14.83	10.75	30.33	16.95	7.6	7.59	-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*	6.61*	1.19	5.55	-2.67**	2.72

Table 3
Time Series Variation in Underwriting Experience
During 1978 - 82 and 1983 - 87 [a]

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.

C. 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.[29] Other Liability Insurance was selected because, among the commercial lines, it experienced the most

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

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 implies 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).[30] Therefore, the evidence in Table 4 does not support the greed hypothesis.

The commission and brokerage expense ratios which 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 evidence would also seem to be inconsistent with the mismanagement and greed hypothesis suggested by NICO.[31]

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

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[30]The 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 policyholders, and other underwriting expenses associated with the development and sale of insurance contracts.

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

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.

Table 4
A Comparison of Variation in Underwriting Experience and Investment Income By Line
During 1976 - 80 and 1986- 88 [a]

Line	Years	Losses Incurred		Loss Adjustment Expenses		Commission and Brokerage Expenses		Other Underwritten Expenses		Policyholder Dividends		Net Investment Gain (Loss) Other Income		Overall Operating Ratio	
		μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
All Lines	76-80	63.6	2.2	9.24	0.21	12.94	0.21	12.96	0.55	1.42	0.26	5.96	0.92	94.18	2.45
	86-88	67.73	2.14	11.57	0.29	11.87	0.06	13.5	0.36	1.33	0.06	9.2	0.44	96.8	1.99
Change		4.13	-0.06	2.33	0.08	-1.07	-0.15	0.54	-0.19	-0.09	-0.2	3.24	-0.48	2.62	-0.46
t or F		2.60**	1.06	13.41***	1.94	-8.52***	12.9	1.49	2.33	-0.55	20.1	5.60***	4.46	1.55	1.51
Homeowner Multiple Peril	76-80	58.48	5.37	7	0.37	18.56	0.36	12.86	0.15	0.64	0.13	16	0.29	94.36	5.21
	86-88	59	2.95	9.5	0.2	16.87	0.31	14.17	0.15	0.53	0.12	4.87	0.12	95.2	3.2
Change		0.52	-2.42	2.5	-0.17	-1.69	-0.05	1.31	0	-0.11	-0.01	1.71	-0.17	0.84	-2.01
t or F		0.15	3.31	10.48***	3.5	-6.70***	1.42	11.77***	1.01	-1.14	1.35	9.56***	6.22	0.25	2.65
Auto Liability	76-80	65.9	2.23	11.38	0.34	10.42	0.26	13.34	0.28	0.88	0.37	6.32	0.64	95.54	2.31
	86-88	81.03	1.17	12.7	0.44	9.43	0.06	13.47	0.21	0.83	0.15	9.5	0.17	108	1.08
Change		15.13	-1.06	1.32	0.1	-0.99	-0.2	0.13	-0.07	-0.05	-0.22	3.18	-0.47	12.46	-1.23
t or F		10.67***	3.65	4.81***	1.62	-6.31***	20.10*	0.67	1.8	-0.2	5.87	8.16***	13.7	8.58***	4.58
Other Liability	76-80	55.14	3.26	19.28	1.03	14.14	0.29	12.86	1.38	0.54	0.09	11.32	2.04	90.66	4.25
	86-88	66.17	5.75	23.83	1.48	10.83	0.64	11.43	1.27	0.23	0.21	15.77	2.4	96.77	5.51
Change		11.03	2.49	4.55	0.45	-3.31	0.35	-1.43	-0.11	-0.31	0.12	4.45	0.36	6.11	1.26
t or F		3.55**	3.12	5.19***	2.06	-10.30***	4.98	-1.46	1.18	-2.99**	5.42	2.81**	1.39	1.77	1.68

a. t (F) statistics reflect test against null hypothesis of equal means (standard deviations).
 *** Significant at .01 level; ** at .05 level; * at .10 level.

Source: The data for analysis in this table was obtained from various issues of Best' Aggregates and Averages, A. M. Best Company.

VI. Conclusions and Policy Implications

The change-in-expectations hypothesis for rational profit seeking insurers in competitive markets seems to be able to explain the major aspects of the commercial liability insurance crisis. A major change in expectations about expected values and variances of losses, expenses, and interest rates seems to provide a cogent causal explanation of the commercial liability insurance crisis.

The proposed microeconomics theory is robust. It can include the tort-law theory, the financial capacity hypothesis, risk theory, the underwriting hypothesis, and more. It provides the basis for testing the collusion hypothesis and the greed hypothesis; the collusion hypothesis has been reject in the literature and this analysis provides the empirical evidence necessary to reject the greed hypothesis.

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 which 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.

Tort reform has been recommended by the Justice Department and the Alliance of American Insurers. 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.

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Other Liability

Year	Premiums	Loss	Expenses	Investment
1981	$ 6,046.00	$ 3,700.15	$ 3,296.16	$ 1,172.92
1982	$ 5,668.00	$ 3,939.26	$ 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**	**$ 4,387.29**	**$ 3,562.65**	**$ 1,397.83**
StDev	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	$ 13,817.93	$ 8,933.38	$ 3,089.35
Mean	**$ 14,565.50**	**$ 10,990.07**	**$ 6,332.69**	**$ 2,458.17**
StDev	6766	3883	2246	584
	5000			
Units	1209200			
Unit Means	4935	3628	2946	1156
Proportional	2.44	2.50	1.78	1.76
Unit StDev	317	724	255	194
Proportional	17.65	4.43	7.28	2.50

Appendix

Theorem. The company supply function is increasing in the surplus if the company utility function exhibits decreasing absolute risk aversion.

Sketch of Proof. Let the function H, i.e., the expected marginal utility, be defined as

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

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

$$\frac{\partial n}{\partial S} = -\,\frac{\dfrac{\partial H}{\partial S}}{\dfrac{\partial H}{\partial n}} > 0 \qquad\qquad (a.1)$$

The denominator is negative due to risk aversion. The sign of this derivative follows if and only if the numerator is positive.

To sign the numerator in (a.1) observe that

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

Let $\ell^* = i\,(1+r)$ so that $\Pi^* = S\,(1+r)$. Note that $\ell < \ell^*$ yields $\Pi > \Pi^*$ and $i\,(1+r) - \ell > 0$. Letting $a = -\,u''/u'$ denote the measure of absolute risk aversion, observe that for $\ell < \ell^*$ we obtain $a(\Pi^*) > a(\Pi)$ and the following sequence of equivalent statements:

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

$$u''\left(\Pi\right) > -\,a\!\left(\Pi\,^{*}\right)u'\left(\Pi\right)$$

$$u''\left(\Pi\right)\left(i\,(1+r) - \ell\right) > -\,a\!\left(\Pi\,^{*}\right)u'\left(\Pi\right)\left(i\,(1+r) - \ell\right)$$

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

$$u''\left(\Pi\right) < -\,a\!\left(\Pi\,^{*}\right)u'\left(\Pi\right)$$

$$u''\left(\Pi\right)\left(i\,(1+r) - \ell\right) > -\,a\!\left(\Pi\,^{*}\right)u'\left(\Pi\right)\left(i\,(1+r) - \ell\right)$$

It follows that

$$\frac{\partial H}{\partial S} = E\!\left\{u''\left(\Pi\right)\left(i\,(1+r) - \ell\right)\right\}$$

$$> -\,a\!\left(\Pi\,^{*}\right)E\!\left\{u'\left(\Pi\right)\left(i\,(1+r) - \ell\right)\right\}$$

$$= 0$$

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